Appendix

Master Thesis report 2017
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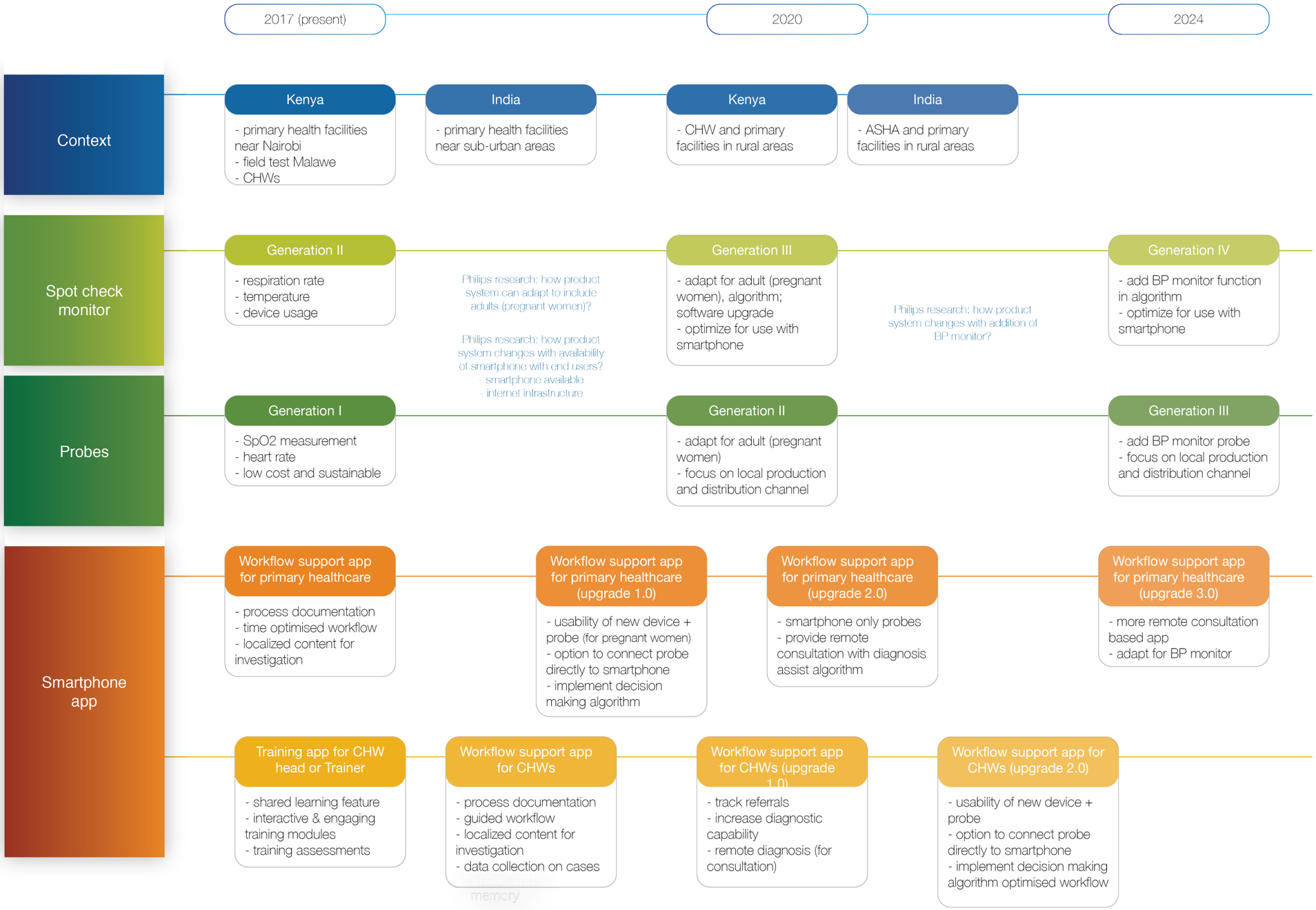
Appendix A


2017 (present)
2020
2024
Context
Kenya
- primary health facilities near Nairobi
- field test Malawe
- CHWs
India
- primary health facilities near sub-urban areas
Kenya
- CHW and primary facilities in rural areas
India
- ASHA and primary facilities in rural areas
Spot check monitor
Generation II
- respiration rate
- temperature
- device usage
Philips research: how product system can adapt to include adults (pregnant women)?
Philips research: how product system changes with availability of smartphone with end users?
- smartphone available
- internet infrastructure
Generation III
- adapt for adult (pregnant women), algorithm; software upgrade
- optimize for use with smartphone
Philips research: how product system changes with addition of BP monitor?
Generation IV
- add BP monitor function in algorithm
- optimize for use with smartphone
Probes
Generation I
- SpO2 measurement
- heart rate
- low cost and sustainable
Generation II
- adapt for adult (pregnant women)
- focus on local production and distribution channel
Generation III
- add BP monitor probe
- focus on local production and distribution channel
Smartphone app
Workflow support app for primary healthcare
- process documentation
- time optimised workflow
- localized content for investigation
Workflow support app for primary healthcare (upgrade 1.0)
- usability of new device + probe (for pregnant women)
- option to connect probe directly to smartphone
- implement decision making algorithm
Workflow support app for primary healthcare (upgrade 2.0)
- smartphone only probes
- provide remote consultation with diagnosis assist algorithm
Workflow support app for primary healthcare (upgrade 3.0)
- more remote consultation based app
- adapt for BP monitor
Training app for CHW head or Trainer
- shared learning feature
- interactive & engaging training modules
- training assessments
Workflow support app for CHWs
- process documentation
- guided workflow
- localized content for investigation
- data collection on cases
Workflow support app for CHWs (upgrade 1.0)
- track referrals
- increase diagnostic capability
- remote diagnosis (for consultation)
Workflow support app for CHWs (upgrade 2.0)
- usability of new device + probe
- option to connect probe directly to smartphone
- implement decision making algorithm optimised workflow

Appendix B

In this chapter, the contexts- India and Kenya are exlpored using a context framework for development of medical devices in low-resource settings. A revised version of this framework consists of physical environment, systems and institutional structures and society & culture. Various context factors from these attributes are studies to identify what are similar and what are opposing using an interactive dashboard. This dashboard is created to explore patterns in insgihts which are later studied in detail.

Research Set-up

As mentioned previously, the contextual research and analysis will be based on the context framework (Clara B. Aranda-Jan, et. al., 2016) for India and Kenya. This chapter will introduce the contexts and the requirements for the embodiment of the product. In the spirit of Context Variation by Design approach, research is conducted from a macro perspective first- with an objective of highlighting the similarities and dis-similarities in India and Kenya. A micro-level context research is also carried out which is discussed in next phase.

Research objectives

Special regard for quantitative data for context research was given, whereas for micro- level context research, qualitative data was given more weightage (in next phase). It was assumed that quantitative data for macro-level context research will help create non-superficial, more conclusive expectations on opportunities and constraints. Qualitative data at macro-level study tend to become abstract and may not guide the designer in solving a problem.
This approach was chosen for a twofold purpose:

1. to construct a data- driven view on the problems and constraints of the people involved in the context of deployment and use
2. to create a foundation for the designer to truly empathise with two contexts- India & Kenya

Research questions

To organise and articulate the research, objectives were used to create research questions.

1. Which contextual factors are highly related to the problem and the concept idea? And which insights regarding the contextual factor are most beneficial to research?

2. Which contextual factors are similar and which are not between India and Kenya?

3. Which contextual factors are highly dependent on prospective end users and sub-systems of proposed concept idea?
4. How can I carry forward the macro- level context throughout the conceptualisation and evaluation phases?

Research breadth and depth

Both the macro contexts, India and Kenya are very diverse. Hence, a more generic quantitative insights are researched. If there is a large breadth of insights, a rural perspective is considered for both India and Kenya. Considering the geographical diversity in India, a insights from Bihar (province state in India) is considered since it is declared as high focus state by WHO and field research was previously conducted by Philips (for Charm design and evaluation).

Research methodology

To meet the requirement of the research questions, several data collection tools were used. Some aspects of the research was based on the previous field- trip experiences both in India and Uganda (since, Uganda is neighbouring nation to Kenya and has similar healthcare system). To start with macro- level research, contextual framework by Clara was adopted. This enabled choice of contextual factors of interest from a holistic perspective.

Desktop research: Various websites were used to gather data but special regards were given to government websites from India and Kenya to gather latest data. The main reason to do so was to gather first-hand data, which has high probability to be related to census (which has large sample size, practically the complete population). Next priority was given to WHO, UNICEF reports and research publications followed by media reports.
Observations from past field trips: The designer has experience from field trips in India and Uganda. Raw data from notes and patient journeys (from group interviews) and videos were used to have deeper understanding and interpretations of the insights at macro- level. Moreover, field trip reports and videos from Philips in Bihar, India and Nairobi, Kenya were also studied.

Revised context framework

The holistic contextual framework from Clara provides four main factors to be studied in order to gauge the context for designing a medical device. These four factors are- Individual, Physical environment, Technical and Systems and structures. But this framework is based upon all the possible medical devices in low- resource settings. Hence, considering the concept idea (type of medical device is known) some of the factors might not be relevant for the project. Therefore, the contextual factors are adopted into relevant contextual factors for this project.

Three main contextual factors were selected to be relevant for project- Physical environment, Systems and structures and Society (originally individual in framework). Technical factors are not considered since the concept idea is not yet completely functional to be considered for manufacturing, and other technological factors. Parts of technical factors were incorporated in the Physical environment category. Systems and structures category was cut down to focus only on insights from public and private healthcare sector.

Appendix C

How can I analyse the insights from context research which best reflects the project's underlying philosophy?

How can I realise requirements for concept detailing from the context research?

Dashboard design

In order to answer the last research question of how to realise the findings of context research into final design, two main approaches were evaluated. The first approach was to convert the insights from the soft and hard requirements. The second approach was to transfer the information into an interactive dashboard in which various patterns, connections between the contexts, proposed concept and personas can be studied. Both the approaches were initially carried out as an experiment to which approach could be better to handle the insights throughout the design process. The pros and cons of both approaches are discussed in following section.

Discussion: systems theory perspective

The two approaches follow from two different ways of thinking- Reductionism and Holism. These are two perspectives on how to best view, interpret and reason about the context. The first approach is the traditional process used to evaluate the ideas and refine the concepts later on in the design process. This follows reductionist way of thinking which assumes that context is constituted by smaller parts (here represented by contextual factors) and thus emphasises the parts rather than whole context. Hence, going by this approach, it is assumed that requirements generated by these factors would help us judge if the ideas will work in the whole context or not.

The second approach is encouraged by CVD mindset and follows holistic thinking. It emphasises the whole context rather than part of the system. Hence, it focuses on how a part (context factor) is part of the larger whole (the context) by studying the relations and functioning. It assumes that the requirements of whole (context) cannot be explained from the requirements of the parts (context factors).

Conclusion

Due to the exploratory phase of the project and larger scope of context (context being the whole country here), the second approach was given a priority. It was also decided here that first approach would be much better applied at micro-context level where the interactions of different parts of the context are clearly identifiable.

A dashboard was created by connecting the Excel file to Tableau software to visualise the various relations of the context factors, proposed concept and personas. These relations were rated on a scale of 1 to 3 by asking open questions for every relation and basing the score with intuition. A provision to choose various attributes using filters is incorporated into the dashboard along with a highlighting feature. This provides freedom for the user of the dashboard to explore focussed patterns. Hence, the patterns derived from the dashboard were further validated through literature study in next phase.

Figure: Representation of context research to be utilized in design process

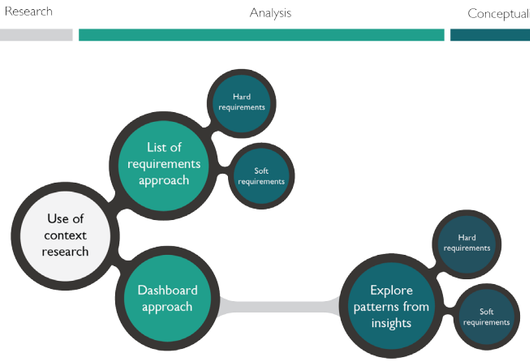


Figure: Designing process of dashboard design, data collection and cleaning in excel and then visulaisatin using Tableau

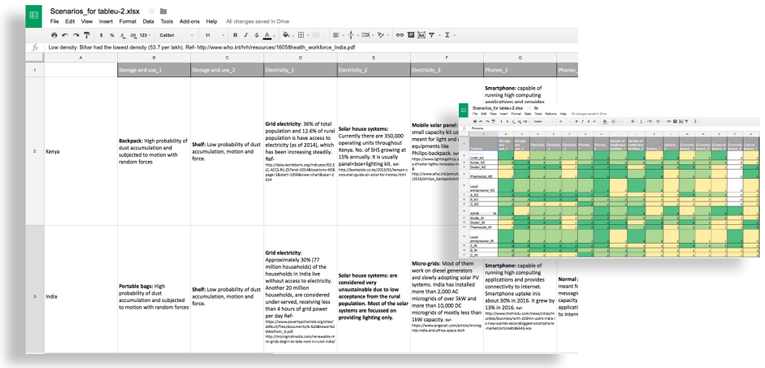


Figure: Final dashboard screens. This figure shows an example of generating patterns among different personas and concerned context factor

The magnified parts show features of filtering out the attributes, freedome to change the legend, and context factors from clockwise (starting from top)

Appendix D

India

1. Majority of the mono-insights were collected from desk research, personal experience (designer is from India) and combination of two.
2. Electricity (2): both first (grid) and second (micro-grid) most available source of electricity are unreliable in India in rural areas. Most of the SHS projects also have been unsuccessful due to scalability challenges especially related to pricing. In-depth investigation suggests that the societal problem lies in people not ready to pay for the electricity, and expect it for free. (confirm with Rhythima, for reference) This influences directly the scalability of the product system.
3. Smartphone availability (3): The smartphone uptake in India is about about 30% and has risen by 13% annually as of 2016. Ref- http://www.thehindu.com/news/cities/mumbai/business/with-220mn-users-india-is-now-worlds-secondbiggest-smartphone-market/article8186543.ece This is lower than Kenya both in terms of uptake and growth. The uptake is used here to indicate if the smartphones are available and if people are familiar with using a smartphone. This may influence the learnability aspect of usability.
4. Public healthcare (2): Public health facilities operational in rural areas provide for free or subsidised services. Most of the staff is reluctant to work in rural areas due to which government has made it mandatory for medical students to serve as part of their curriculum. Although some of the staff is posted from same local villages, others are low on motivation and eager to move to urban areas. This influences the usability aspect in the project.
5. Private healthcare (3): Most of the facilities are private both in urban and rural areas reaching out to 70% and 63% households respectively Ref- International Institute for Population Sciences and Macro International (September 2007). “National Family Health Survey (NFHS-3), 2005–06” (PDF). Ministry of Health and Family Welfare, Government of India. pp. 436–440. Retrieved 5 October 2012
6. Payment of health services (1): Emergent cases in rural areas are usually supported by money-lenders. Money-lenders are usually rich members (often affiliated to politics) of the village. Money lending comes at a heavy interest rate (as high as 20%) which is usually paid in form of kind. During emergent cases, people usually prefer to go to private hospital due to perception of better care (since they take money).
7. Society (2): About 80% of the population identify themselves as hindus Ref- http://www.thehindu.com/news/national/Muslim-population-growth-slows/article10336665.ece However, more importantly, caste system is more prevalent and is embedded into settlements, festivals and work. Caste hierarchy system implies various rules such as- members of upper caste may not talk, visit or touch members from lower caste and vice versa.
8. Lowest level health workers (3): The ASHA workers are women and are paid on the basis of their performance (no. of home visits, etc.). Married, widowed or divorced women are preferred over women who have yet to marry since Indian cultural norms dictate that upon marriage a woman leaves her village and migrates to that of her husband. Ref- http://nhm.gov.in/communitisation/asha/about-asha.html
9. Language (3): Hindi and English are spoken widely (mainly in North India), but still large population at district level cannot speak or understand Hindi or English (for example south India). Ref- http://timesofindia.indiatimes.com/india/Nearly-60-of-Indians-speak-a-language-other-than-Hindi/articleshow/36922157.cms Hence, at local village level, there is a high probability that only regional language is used rather than Hindi or English.

Kenya

1. Insights were collected from desk research, on-field expert interview and personal experiences. On-field expert is a Philips employee stationed at Nairobi who has done numerous user interviews and field research on healthcare. The designer has field experience from Uganda (neighbouring country of Kenya), which is very similar in terms of context. Hence, the personal experiences are taken into account with caution.
2. Electricity (2): Most widely used sources of electricity are grid and SHS. SHS due to its low capacity, is mainly targeted for lighting purposes only. But the success of SHS projects suggest that people are willing to pay for the electricity unlike India.
3. Smartphone availability (3): Smartphone penetration in Kenya is increasing rapidly due to introduction of cheap phones from Chinese manufacturers but this is widely distributed across population. Smartphone uptake in Kenya was 44% in 2016 and is growing by about 10% annually. Ref- http://www.moseskemibaro.com/2016/10/01/kenyas-latest-2016-mobile-internet-statistics/
4. Public healthcare (3): All the services by the government are free. Although, public healthcare faces great challenges in terms of lack of workforce, and resources. Thus major policy reforms have been made to encourage private sector by allowing the staff to work at both public and private facilities, introducing small patient fees.
5. Private healthcare (3): Private health facilities are growing in number due to above said policy reforms by the government. Also, they were also scaling up due to poor accessibility of public health services.
6. Payment of health services (2): Public health services were till now free, but government has introduced a patient fees for some of the services. Private sector costs are still higher but it is perceived as better quality care. In case of emergent cases, money is loaned by companies which facilitate the transfer through mobile-money. Ref- http://www.loans.info.ke/2015/01/emergency-loan-givers-in-kenya.html These companies are most of the time subsidiaries of banks and telecom operators.
7. Society (2): 82% of the population is christian and 11% of it is muslim. However, ethnic groups are present in the rural areas who influence the workings, behaviours in the society. Research suggests the religious or ethnic values are reflected in deciding if the sick child is taken to traditional healer or health facility. Ref- Abubakar, A., Van Baar, A., Fischer, R., Bomu, G., Gona, J. K., & Newton, C. R. (2013). Socio-Cultural Determinants of Health-Seeking Behaviour on the Kenyan Coast: A Qualitative Study. PLoS ONE, 8(11), e71998. http://doi.org/10.1371/journal.pone.0071998 Father of the household is usually the decision making person on when, where to seek care.
8. Lowest level health worker (3): The community health worker (CHW) works voluntarily without payment. They are chosen by the community and hence see themselves as leaders who take pride in educating and helping the sick people. Unlike Indian ASHA workers, there are not restrictions on gender or age of the CHW. However, it is important to note that the health workers are unpaid yet motivated to work for their community.
9. Language (3): Swahili and English are most widely spoken languages which is also used in medical systems. But there are some rural areas where even Swahili is not used and specific local languages are used for communication.

Appendix E

Link to user research results from cultural probe-
https://docs.google.com/spreadsheets/d/1Xda9JTt1XC2tFwZsR4Gj7iGxh81HM-N2QNBLROXBzY4/edit#gid=0

User research results

File Edit View Insert Format Data Tools Add-ons Help Last edit was 1 day ago

vinmmb@gmail.com

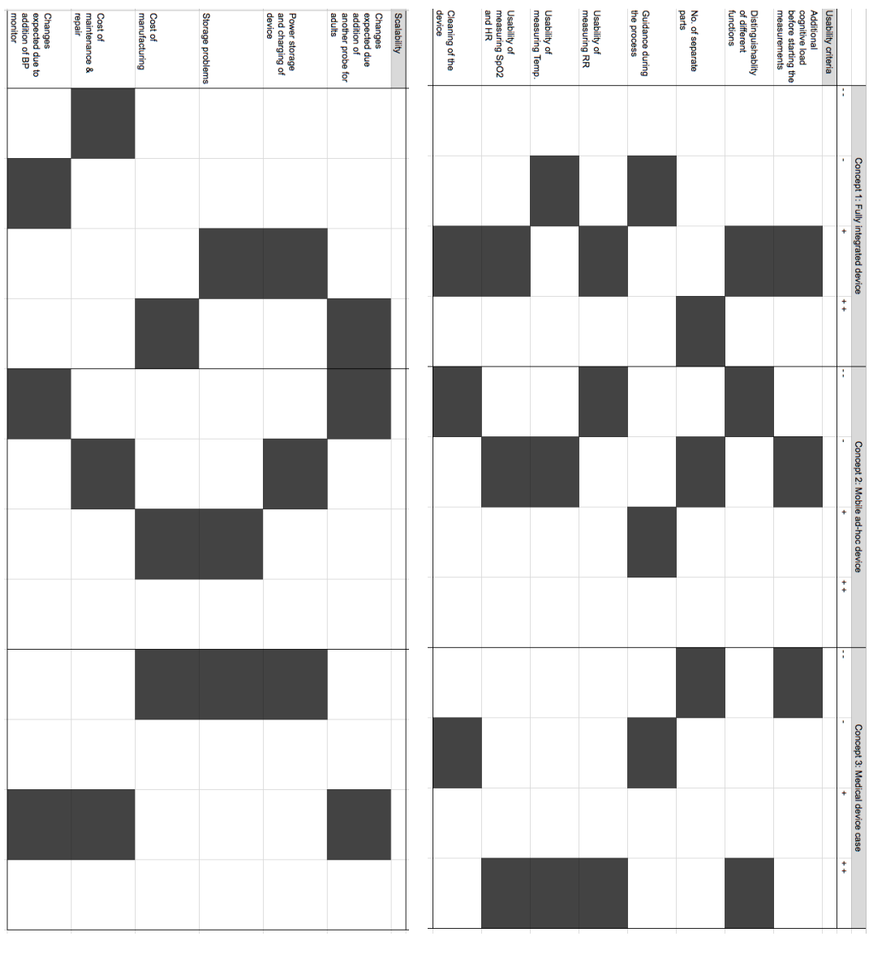
Comments Share

Arial 10

fx Persona

	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1	How do I work?					What problems I face?					How is your day?					What could be b
2	When sick child comes	First thing I do	During the screening I pay attention to	During the screening I have to remember	End of screening I focus on	Best part of process	Worst part of process	Start	During	End	How many children do you see everyday?	How much time do you spend screening them everyday?	Task	time	difficulty	Technology can help in
4									Language barriers				Send patients to lab	1	1	
5													Patient examintation	2	1	
6													Make diagnosis	1	1	
7													Write prescription	1	1	
8													Educate caregiver	1	1	
9													Give first aid	1	1	
10	Child symptoms, severity and vitals; also look at nutritional status	Ask caretaker history, when symptoms started, how long they are there and judge the severity	How active the child is according to the age	What to advice on treatment, possible danger signs and good nutrition to the caregiver	Judging the severity of condition of child and best suitable medicines	Caregiver appreciating my work and saying she wishes more children to be treated by me	Un-cooperative caregiver who do not follow my instructions	Too many children with emergency needs (high temp. vomitting, dehydration)	Un-cooperative caregivers, not telling all the problems	Child developing complications because caregivers are not able to access the medications	80	8 hours	Take medical history	3	1	Taking vitals
11													Examination	2	2	
12													Take vitals	2	2	
13													Making diagnosis	1	1	
14	Behaviour of the child	Check the vitals like temp., access dehydration, etc.	Medical history, repetitions in symptoms; behaviour of caregiver and behaviour towards the child	Major symptoms presented, behaviour of child and caregiver	Possible diagnosis, medication management, screening of other members in case of contagious disease	Satisfaction of caregiver and child	Lack of equipment for measuring vitals and non-cooperative caregivers	Irritated child, language barrier, lack of co-operation of caregiver and equipment failure	Irritated child, language barrier, lack of co-operation of caregiver and equipment failure	Lack of medicines in hospital, lab technicians	50	8 hours	Assessments-2min	3	2	Accessing information for complicated cases; easy communication for follow-up; consulting a specialist
15													History-3min	3	2	
16													Vitals-2min	1	2	

Appendix F



Appendix G

Desirability										
Feasibility										
Viability										
	Perceived usefuln	Improved usabilit	Adapted to local	Easy to learn to u	Technically possi	Time for impleme	Additional humar	Low risk of imple	Cost of product s	Reduction of ope
Perceived usefulness		1	1	0	0	0	1	1	1	1
Improved usability	1		0	0	0	0	0	0	0	0
Adapted to local context	0	1		0	1	0	1	0	1	1
Easy to learn to use	1	1	1		0	1	1	1	1	0
Technically possible in present	1	0	1	1		0	0	0	0	0
Time for implementation	0	1	0	1	1		0	1	1	0
Additional human resources	0	1	0	0	0	0		1	1	1
Low risk of implementation	0	0	1	1	1	1	0		0	0
Cost of product system	1	1	1	0	0	0	0	1		1
Reduction of operational tasks	0	1	1	0	0	0	0	0	1	
Weighted average	0.444	0.778	0.667	0.333	0.333	0.222	0.333	0.556	0.667	0.444

	Perceived usefulness	Improved usability	Adaptability	Easy to learn to use	Technically possible in present	Time for implementation	Reduction of human resources	Low risk of implementation	Cost of product system	Reduction of operational tasks	Total score
Weighted average	0.444	0.778	0.667	0.333	0.333	0.222	0.333	0.556	0.667	0.444	
Concept #A1	2	1	1	2	2	2	2	2	2	1	1.604651163
Concept #A2	1	2	2	1	1	1	1	1	1	2	1.395348837
Concept #P1	3	2	3	2	3	3	1	3	2	2	2.395348837
Concept #P2	2	3	1	3	1	2	1	1	3	3	2.069767442
Concept #P3	1	1	2	1	2	1	1	2	1	1	1.325581395

Appendix H

User interaction scenarios

After exploring the barriers and creating the personas, all the insights gathered are collected into two main user interaction scenarios- low expertise scenario and high expertise scenario. The purpose of the user scenarios is to consolidate main insights from user research in a more holistic form. This would enable providing context to mono-insights and creation of more informed solution space. Low expertise scenario is representation of possible scenarios where lowly educated health worker (CHW) is using the IMCI guidelines. A high expertise scenario is representation of possible scenario where highly educated health worker (clinical officer) is using IMCI guidelines.

LOW expertise scenario

Mary is a CHW living in rural Kenya about 100km away from the capital, Nairobi. She checks her agenda from the diary in the morning. She notices she needs to do few follow up visits and do an assessment because her neighbour told that Jane (a 2 year girl in neighbourhood) is sick. She takes her bag, with IMCI chart, thermometer, medicines, and her reporting notebook.

During her follow up visit, she looks up the past assessment and action. After going into the house, she exchanges greetings and asks how is everybody in the family. Then she washes her hand, and while doing so checks if others in the family are doing so or not by asking the caretaker. She then checks on the sick child and finds some of the symptoms still exist. She does an assessment using IMCI chart but refers to the booklet again and again while doing so. Due to this, she takes longer time than expected. Sometimes she repeats her questions because she forgets what the caretaker told her. At the end, the chart says child is low risk and gives then she gives advice based on IMCI with some medication.

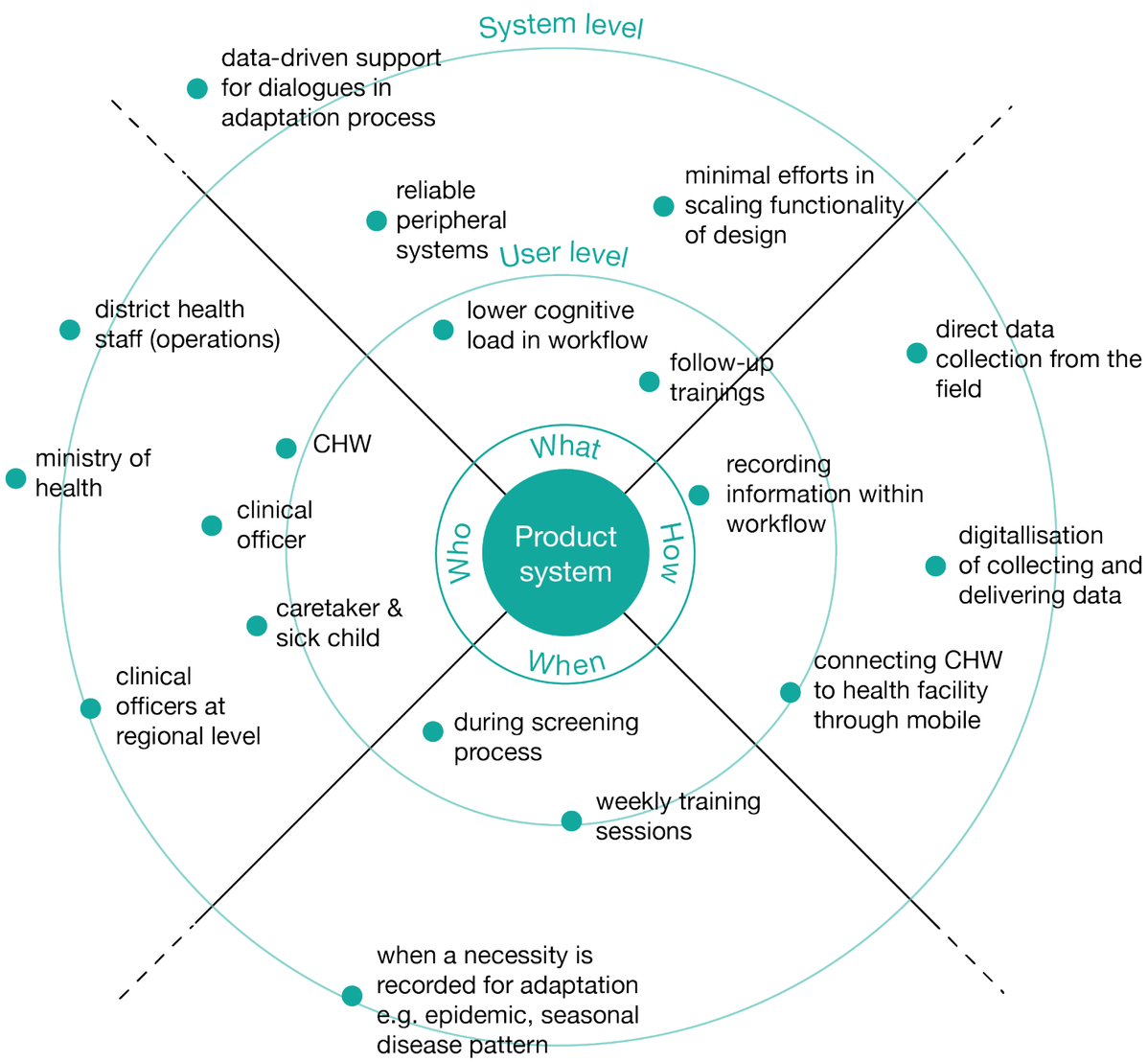
Mary then goes to look for Jane, she has not been there often. While arriving at the door, she greets Jane's mother and tell her purpose of visit. Slightly reluctant, the mother starts talking at the door to see why exactly Mary is visiting. On insisting, mother invites Mary inside and looks at coughing Jane. She begins to ask questions but the mother seems non-cooperative while answering. To gain mother's trust and respect, Mary starts asking questions while checking signs and symptoms on Jane. Mary then explains the importance of those questions and checks the temperature of Jane. Mary tries to use IMCI chart to assess Jane, but she experiences difficulties because on top of referring again and again, she has to remember key points from training to explain the importance of task to mother. Mary finds that Jane is at high risk, she immediately writes a referral letter and gives medicines. The mother is still not convinced that Jane needs to visit the facility, but Mary tries to convince her with her knowledge from trainings.

HIGH expertise scenario

John is a clinical officer near Mary's village about 30km away. He studied to be a doctor for 8 years and has been practicing for 5 years. He handles the health facility which has a lab technician, a nurse and 2 beds. He sees about 40 sick children and spends about 8 hours everyday.

John welcomes a mother with sick child in the afternoon. He checks the general condition of the sick child and checks what nutritional diet and immunisation they have been following. He pays attention to the behaviour of child, and mother's behaviour towards the child to gauge how he should talk to mother. He follows IMCI but due to lot of practice, he only refers few times. Since mother came from slightly distant village, he faces difficulty due to language while explaining his findings. Judging the symptom, severity and history, he tells the mother to get some lab tests done and explains his conclusion. Once the lab test are done, he checks and provides medications. He takes extra care to convey what dosage and why he is giving the medicine to the mother.

Appendix I



Appendix J

Link to user research results from user interviews-
https://docs.google.com/spreadsheets/d/1Xda9JTt1XC2tFwZsR4Gj7iGxh81HM-N2QNBLROXBzY4/edit#gid=2127366436

Persona	Insights from the probe	Insights from concept					
		Do you like it?	Training feature	Screening feature	Impact on the work	Problems they envision in common practice	Any comments
Clinical officer	Had trainings from MoH on Malaria, HIV and TB, which I enjoyed. Would like more and different ones. **Highlighted problems**: High workload and urgent referrals level causing financial strain. **Mitigation**: Refer to higher facility; prescribe drugs, not lab tests.	Preliminary screening and training content is fine, but need more advanced level content.	It should have more advanced features, like differential diagnosis.	Should list common symptoms based on region based on the reports they make. Change symptoms according to medical lingo.	Will make screening faster and better. Improvment in quality and reduced time in managing the patient	What if the app crashes, can data still be retrieved?	The app should be integrated with CHWs, to enable referal and knowledge support.
Clinical officer	No trainings after first training; only CMEs' which are not consistent **Highlighted problems**: Incoherent info. from caregiver. **Mitigation**: Give more time for caregiver to talk, extend the screening over 2 days to let her relax.	It seems more reliable, and will reduce revisits of patients and hence the workload as well It should have both under and over 5 children, helps to integrate them into one app.	Desire not to be connected to internet all the time, and can use it everyday. It looks useful and should be available to both clinical officers and nurses as all are updated on the trainings Can use it everyday.	Will make screening easy, as I won't miss any data during the process. Should facilitate recording new symptoms.	Patient/Caretaker perception: positive I don't miss on any information and vital measurements, so the quality will improve It should have advanced features to enable back-end decision support. Will lead to higher quality and reduced time for screening. Perception: it will help the caretaker disclose information	The app may take time in the beginning to get used to. It may take longer time to manage patients	
Clinical officer	**Highlighted problems**: High workload. **Mitigation**: Prescribed drugs without any lab results	Simple to navigate but shallow on content	Will use it everyday, but more to store information.	It should have more advanced content	Will make decision making easier and time shorter.	What happens if the app crashes.	Should be integrated into EMR, and also be connected with CHWs. It should receive information from them directly.
CHW	Follow-up trainings were given to few, 2 CHWs were selected from every village.	It is simple to use, and understand. Would help in assessments.	The training modules are clear but the storyline is not clear and hence not relatable.		Caretaker will have positive impression while using the app. Will help caretakers to be specific. Reduce the work during the visit, reduce time as well. I can do more home visits. It will enhance my judgement as it will summarize the visit.		Add SMS feature to send reminders. It should share highlights of the visit. Patient registration shold be customised e.g. include house no.