UiO : Department of Informatics
University of Oslo

Dashboard Design Guidelines for Improved Evidence Based Decision Making in Public Health in Developing Countries

Simon Jespersen

Master's thesis Spring 2017

Dashboard Design Guidelines for Improved Evidence Based Decision Making in Public Health in Developing Countries

Simon Jespersen

Spring 2017

ABSTRACT

DHIS2 has established itself as de facto standard for health management information system in developing countries. While DHIS2 provides tools for collecting, analysing and visualising data, history shows that data is often not being used for evidence based decision making.

This thesis will look into facilitating improved evidence based decision making through improved dashboard design. This is a part of a larger initiative by HISP UiO to enable DHIS2 being used as an integrated disease surveillance and response (IDSR) system. This thesis identifies dashboard design guidelines and tests them in practice by developing a prototype for an emergency operation centre (EOC) dashboard in Uganda. Additionally, standard DHIS2 dashboards are analysed using the guidelines to test their relevance and to improve dashboards for decision making.

The requirement gathering for the EOC dashboard prompted a field trip to Uganda. HISP Uganda presented a proposed IDSR system and the requirements of the EOC dashboard were discussed together with the EOC in Uganda.

Broadly, this study shows that there are many reasons why evidence based decision making is lacking. For example, the gap between expert and novice users where having too many options will overwhelm novice users while having too few will hinder the experts in their analysis. The main contribution of the thesis is a set of dashboard design guidelines. I show how these design guidelines fit better with tailored dashboards, where a developer creates a dashboard for a specific purpose and users. Looking at the guidelines in the context of user created dashboards, the approach used for making DHIS2 dashboards, two sets of guidelines are made: guidelines for developers and guidelines for dashboard creators.

The thesis also shows that there are still missing features in the data visualisation part of DHIS2 that could yield value if implemented. Additionally, the thesis provides an EOC dashboard prototype and discusses how this can be improved further with the use of the dashboard design guidelines.

ACKNOWLEDGEMENTS

First I would like to thank my supervisor Petter Nielsen for guiding me through this thesis, discussing ideas and providing helpful feedback. I am also thankful for Ola Hodne Titlestad who has provided valuable guidance and discussions during this thesis. I would also like to thank Prosper Behumbiize for allowing me to come to Uganda and work with him during my stay there. Finally, I would like to thank my family and friends for motivating me through my many years in school.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The Ebola epidemic that started in December 2013 in West Africa was a reminder that there is a strong need for a common Integrated Disease Surveillance and Response (IDSR) framework for developing countries. An IDSR framework will strengthen disease surveillance and response by involving all the health levels in the process, it relies on cooperation and feedback for all the levels.

The DHIS2 software is a Health Management Information System (HMIS) used for collecting, analysing and visualizing data for public health in developing countries. It is used in over 50 countries across four regions, but mostly in the African region. With DHIS2, health workers can report data on any type of device, either through a web interface, by sending SMS or by using one of the mobile applications that DHIS2 provides. It is used primarily for weekly and monthly reporting of routine data, but the Ebola outbreak has led to an increased focus on strengthening it into an IDSR platform.

DHIS2 is very flexible and can present data in different ways, which includes maps, charts and tables. It is a free open source project with a RESTful[1] web application programming interface (API) that makes it easy to make additional applications for it without changing its core. Since DHIS2 is well established in many countries it will be a good base to build upon instead of creating a whole new system. A common problem in these developing countries is that new projects gets funded, but is abandoned after the pilot.

[1] http://stackoverflow.com/questions/671118/what-exactly-is-restful-programming

An IDSR framework involves many factors (Nsubuga et al., 2010, pp. 14-15), both technical and non-technical, but this thesis will focus on how DHIS2 can be used as a surveillance and response tool in the IDSR framework and more specifically look at how disease outbreak data can be presented as a dashboard. Outbreak data shows how many cases has been recorded of a disease in a given time period in a given area. If the number of cases exceeds a defined threshold, the dashboard should get the attention of and alert relevant stakeholders and support their actions based on the data that is presented. This will help to address one of the key challenges today: health managers do not use collected data to monitor and identify potential outbreaks. It is rather common that the health authorities usually get this information from newspapers, word of mouth or rumours.

This thesis will explore how to communicate IDSR data through a dashboard. Current guidelines for dashboard design will be explored and they will be the basis for this project. The dashboard design guidelines will be looked at and if necessary adapted to public health data. In DHIS2, users can create their own dashboards, but the flexibility of it both have benefits and faults, which will be explored. Further, a prototype which will follow the guidelines will be developed in the context of IDSR, addressing the requirements of the Emergency Operation Centre (EOC) in Uganda. Gathering requirements for the EOC dashboard was done in a field trip to Uganda, where many meetings were attended, including one at the EOC itself. Evaluation of the prototype is done through remote testing by one of the health workers at the EOC. Though the dashboard design guidelines will be tested for IDSR data, they should be general enough to be applied to all DHIS2 dashboards and be easy to follow for dashboard creators.

1.1 Research Aim

A lot of information is collected in the public health sector in developing countries. The data is reported into the HMIS system for the ministry of health and other stakeholders to view, but the data can and should be used in more ways to improve the health systems. The data needs to be processed and output in a meaningful way for data analysis so the health workers can act upon it. As data presentation will play a big role in an IDSR system it is important to get it right. Currently, it is primarily rumours and word of mouth that indicates when there is a disease outbreak. With better use of the already collected data, it will be possible to detect some of these outbreaks earlier and this can lead to faster response and more lives saved.

This study is set in the context of data presentation in IDSR, but it is a part of a larger challenge; how to do we present public health data so it can and will be used to support evidence based decision making?

Dashboards are a way to quickly show data that should be meaningful to the user here and now. This thesis will try to address the issue by researching dashboard design guidelines in the context of public health data for IDSR. The research question is as follows:

- Can improved dashboard design facilitate improved evidence based decision making in public health for developing countries?

There are multiple goals of this thesis. First, it should identify general dashboard design guidelines. Second, it should provide an overview of a suggested EOC dashboard and a prototype. Lastly, based on the EOC dashboard and prototype, it should provide dashboard design guidelines for dashboards in public health in developing countries, more specifically for DHIS2. These goals should be reached by doing two case studies: First, understanding and prototyping an EOC dashboard for the EOC in Uganda, and second, studying how current dashboards in DHIS2 are built and how these could be improved by dashboard design guidelines.

1.2 Structure of Thesis

Chapter 2: Background – Will provide the necessary background for this thesis. This includes information about IDSR, DHIS2 and dashboard design. Lastly, information about Uganda will also be provided.

Chapter 3: Method – The case study method will be explained and the alternative action research will be described. Further, how the case study method was used to conduct the research is also described.

Chapter 4: Developing a Dashboard – It covers the requirements gathering and development of the prototype EOC dashboard.

Chapter 5: Dashboard Design Guidelines in DHIS2 – Analysing DHIS2 dashboards to see if they follow the dashboard design guidelines and if not how can they be improved by doing so.

Chapter 6: Discussion – Discusses findings and observations from the two previous chapters.

Chapter 7: Conclusion – It covers the conclusion of this thesis and suggested future work.

2. BACKGROUND

This chapter provides background information for all the factors of this thesis. First, defining what an IDSR system is as described in the IDSR technical guidelines (Nsubuga et al., 2010) and how it is meant to implement the International Health Regulations (IHR). It will then cover how a dashboard should be designed by describing current design guidelines. These guidelines will later be evaluated to see if they fit the needs of public health data dashboards. The DHIS2 software, which the EOC dashboard will be built upon, will be presented to get an understanding of the underlying architecture and how this affects how the dashboard should be created. Finally, background information about Uganda will also be provided, as this is where the requirement gathering happened for the EOC dashboard.

2.1 Defining an Integrated Disease Surveillance and Response System

Created by the members of the World Health Organization's African Regional Office in 1998 (Nsubuga et al., 2010, p. 2), the IDSR strategy is a response to the outbreak of several communicable and preventable disease in Africa. With the right systems in place, these outbreaks can effectively be prevented and this is what the IDSR strategy aims to achieve. IDSR is a regional framework meant to make it easier to detect and respond to diseases in developing countries. It specifies 40 prioritized diseases and conditions, which is mostly diseases that are possible to prevent. The strategy is a cooperation covering all levels of the health system.

2.1.1 International Health Regulations

When there is a disease outbreak in a country, it can also affect other countries over time, that is why we have the IHR. The regulations were originally written in 1969, but were later revised in 2005 to be more future proof. It was the severe acute respiratory syndrome (SARS) outbreak in 2003 that was the reason the IHR was revised (Center for Disease Control and Prevention, n.d.). As the original IHR only covered three diseases, the revision was severely needed as cross-border travel and trade were increasingly common. The IHR now covers both old, new and re-emerging diseases to reduce the risk of spreading diseases internationally.

The IHR is a legally binding agreement, that every country that is a member of the World Health Organization (WHO) is required to uphold. The goals of the IHR is to be able to detect, assess, report and respond to public health events. The goals were set to be completed by 2012, but has been extended multiple times due to very few of the countries being able to fully implement a fully working system (Center for Disease Control and Prevention, n.d.). The IDSR framework is a platform that can be used to implement the requirements set in the IHR.

2.1.2 The Components and Roles of an IDSR

As described in the IDSR technical guidelines (Nsubuga et al., 2010), there are a lot of components and roles involved in an IDSR framework, both technical and non-technical. The reason for all the components to be integrated into one system is so that there is one standard system that will be used, instead of having many fragmented. This means all resources should be dedicated to this system.

Further, the guidelines explain that in the integrated system, there should be standard forms for reporting data so that the data will be consistent and there should only be one data entry system, in our case DHIS2. A common problem is that reporting forms have been too complicated and the health workers don't take the time to fill them out, this leads to less reporting of data, as well as less timeliness of reporting if the health workers delivers the reports late. The system should also be used as a communication channel for feedback and training.

> *"IDSR involves nearly full time coordination of surveillance activities and joint action (planning, implementation, monitoring, evaluation) whenever it is possible and useful." (Nsubuga et al., 2010, p. 7)*

2.1.2.1 Health System Levels and Their Role

The health system is divided into different levels, how many levels depends on each country, but the IDSR technical guidelines (Nsubuga

et al., 2010) has simplified it to four main levels. Different data is useful for the different levels.

Community level: This is the lowest level in the health system and is where the community health workers (CHW) perform health services. This includes trained birth attendants, veterinaries, pharmacists etc. Data collection is usually done by filling in forms and delivering them to health facilities, but since mobile phones has gotten a lot cheaper and the coverage of telecom services has expanded it is possible for CHW to report data directly into the system (DHIS2) using their own phone, though this depends on the infrastructure and resources that is available in a country.

Health facility level: The second lowest level is the health facility level, it includes health clinics, both public and private. This level is usually where the CHW will report their data to unless they have access to SMS reporting. The health facility aggregates all the data they have collected and deliver it up into the system at the district level. It is unusual for health facilities to have access to a computer or internet so if they cannot report their data using SMS, they must also deliver their paper based reports to the level above.

District, region or province level: Some countries split this level into more levels, for example district and region levels depending on the population it will serve. In general, this level includes district hospitals and district health offices, and is the second highest level. The district health office governs the health facilities that is in the district, when they receive data from the lower levels it will be entered in to the HMIS system at this level.

National level: The national level is the highest level in a country and it is where the decision making and resource allocation is done. This level includes the Ministry of Health (MoH).

The integrated system aims to simplify the data reporting across all the levels of the health system, and as mentioned earlier it should be a communication platform between the levels, so that each level can receive feedback.

2.1.2.2 Surveillance Functions

There are eight steps in IDSR. In the IDSR technical guidelines (Nsubuga et al., 2010) they are described as a list of steps that can be performed across multiple levels in the health system, though different levels do not perform identical functions. The steps are listed in short below, more detailed information about each step can be found in the IDSR technical guidelines (Nsubuga et al., 2010)

1 Identify disease cases and events.
2 Report the suspected cases.

3 Analyse and interpret findings.
4 Investigate and confirm the cases, outbreaks or events.
5 Prepare the response.
6 Respond to the events.
7 Provide feedback to the involved health workers.
8 Evaluate and improve the system.

2.1.3 Reporting Data

Reporting data has traditionally been done by delivering paper forms up through the system (Nsubuga et al., 2010, p. 84). That means the CHW fill in a tally sheet that they deliver to health facilities, the health facility aggregates the data and delivers it to the district level, for example at a hospital. The same process is repeated here and delivered to the national level or entered in to the HMIS system if the district has the resources for this.

The old way of reporting is not very effective. The paper forms can easily be lost or destroyed in transport. Another problem with this method includes forms never being delivered, it might be too expensive for the health workers to travel to the nearest health facility or they are not motivated to do so. Sometimes incentives are made to get health workers to gather data. Though incentives can be a good way to ensure data collection, it can also be abused by the wrong person. A health worker can fill in dummy data just to get the incentives.

With the prevalence of mobile coverage and decreasing handset costs, the reporting of the data can be done in a simpler way. DHIS2 lets a user report data using SMS, phone applications or the web. This can potentially remove paper based forms completely and it can help in standardizing forms.

Reporting data has usually been done on a weekly, monthly or quarterly basis, but with IDSR immediate reporting is also necessary. Due to the increase in mobile coverage and low cost of handsets, immediate reporting can potentially be done at the community level.

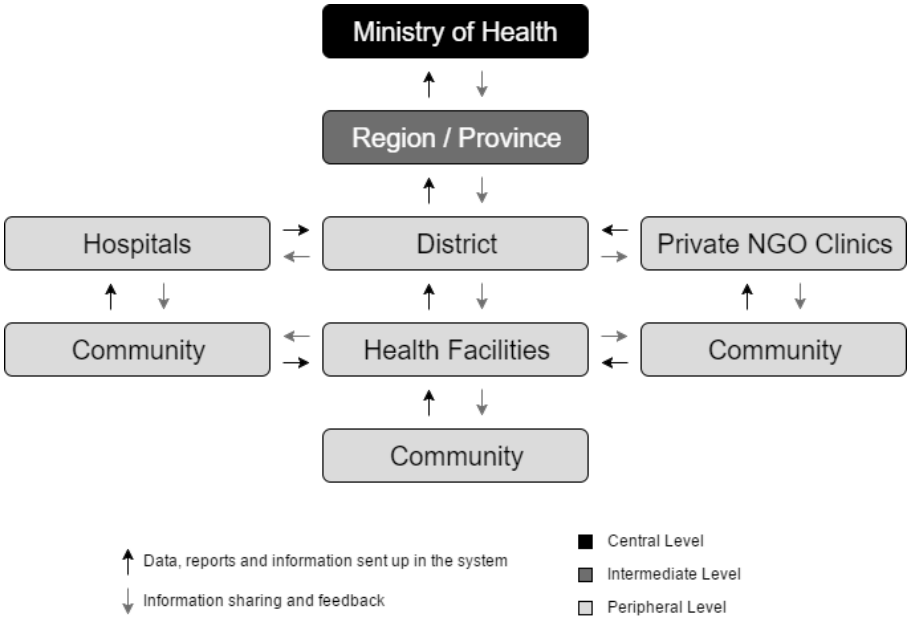


Figure 2-1: The information flow in integrated disease surveillance. Adaptation of figure from Nsubuga et al. (2010, p. 84).

2.1.3.1 Which Data is Needed?

As the IDSR technical guidelines describes (Nsubuga et al., 2010), the data collected needs to be consistent and standardized. A problem has been that forms are too specific for each registration. It can be very tedious to collect information that might not seem useful, but that might be useful for the higher levels in the health system. The data collected will also vary depending on which disease it is. It is important to have standard case definitions, but equally important is the ability to report new conditions for disease we might not know about.

Minimum dataset is a term used in IDSR. Only the important information that is needed for decision making and analysing an outbreak should be collected. There will be a lot of "nice to have" data that the higher levels would want, but this is not essential and therefore should not be included as this will only make the reporting process more tedious and won't give any significant value.

2.1.4 Analysing Data

To make good use of the collected data in surveillance, it needs to be analysed and to do that it is important to structure the data. This means that raw data alone is not very helpful when analysing, it needs to be aggregated and organized into relevant categories. This will help in

getting a broader picture of the situation, and from that it will be easier to observe trends. Data should also be categorized so that analysis can be done based on geographical location, age groups, gender and time.

Type of analysis	Objective	Tools	Method
Time	Detect abrupt or long-term changes in disease or unusual event occurrence, how many occurred, and the period from exposure to onset of symptoms.	Record summary totals in a table or on a line graph or histogram.	Compare the number of case reports received for the current period with the number received in a previous period (weeks, months, seasons or years)
Place	Determine where cases are occurring (for example, to identify high risk area or locations of populations at risk for the disease)	Plot cases on a spot map of the district or area affected during an outbreak.	Plot cases on a map and look for clusters or relationships between the location of the cases and the health event being investigated.
Person	Plot cases on a map and look for clusters or relationships between the location of the cases and the health event being investigated.	Extract specific data about the population affected and summarize in a table.	Depending on the disease, characterize cases per the data reported for case-based surveillance such as age, sex, place of work, immunization status, school attendance, and other known risk factors for the diseases.

Table 2-1: Overview of types of analysis (Nsubuga et al., 2010, p. 87)

Clean data is important; which means that the data is correct. There are several ways for data to be wrong, and it is often due to human error when submitting or aggregating the data. To keep the data clean, there are several practices that should be followed when submitting reports (Nsubuga et al., 2010, p. 86):

- The data needs to be submitted in a timely manner, so that discrepancies can be checked and fixed as soon as possible. If data is submitted into the system too late, someone might not bother to fix it. This will impact analysis later when data is compared to earlier periods.
- When no cases were reported, it is important that a zero is written in the system so when someone is looking at the data they know that there were zero cases. If the field is left blank, it is hard to know if there were no cases or if data was not reported.
- Late reports must be entered in to the week it was supposed to be reported, not into the current week.
- Do not duplicate reports.

- Provide feedback to the ones who enters the data into the system, so that they know if they are doing something wrong. People can't improve unless they know that they are doing something wrong.

2.1.4.1 Thresholds for Public Health Action

For each disease, there is a threshold that indicates when action should be taken. The thresholds depend on many factors, and there are two types of thresholds; alert and epidemic. When the alert threshold is exceeded, it tells the health workers that investigation is needed, while if the epidemic threshold is exceeded, a response is triggered immediately (Nsubuga et al., 2010, p. 97).

Each week will have a set threshold for a disease, there are many factors at play when it comes to defining it. Some diseases, like Malaria, will have seasonal trends, while others, like Ebola, will have a static threshold. Some of the factors for defining the threshold can include location, population and time of the year. If there is a lot of refugees coming into a country, there might be refugee camps. The threshold here needs to be lower, because the chances of a disease spreading is so high.

Clean historic data is important when looking for trends and predicting outbreaks, and will help with setting future thresholds.

DISEASE NAME / CONDITION	ALERT THRESHOLD[1]	ACTION THRESHOLD[1]
Acute Flaccid paralysis (AFP) / Polio	1 suspected case	1 confirmed case of Polio
Bacillary dysentery[2]	An unusual clustering of cases (5 or more) in a parish in a week	Two consecutive weeks with cases above the alert threshold Any increase in number of deaths due to bloody diarrhea
Cholera[2]	1 suspected case in the area or in the neighborhood	1 confirmed case (where it has not been reported before)
Diarrhea under five	Increasing number of cases in a short time	Increasing number of cases in a short time
Guinea worm	1 suspected case	1confirmed case
Anthrax	1 suspected case	1confirmed case
Acute Viral Hepatitis	1 suspected case for the epidemic prone types	1confirmed case for the epidemic prone types
Small pox	1 suspected case	1confirmed case
Influenza Like Illness (ILI)	A cluster of suspect cases	1confirmed case with influenza due to a new sub-type
Severe Acute Respiratory Syndrome (SARS)	1 suspected case	1confirmed case
Injuries		**RTA:** 50 case fatalities per 100,000 population. (District specific threshold required) **Burns:** One severe burn **Poisoning:** 2 cases **Drowning:** 2 cases
Leprosy	1 suspected case	1 confirmed case per 10,000 population (

Figure 2-2: Alert and epidemic threshold for some of the priority diseases in Uganda.

2.1.5 When an Alert or Outbreak Occurs

In case of an alert or an outbreak, health personal must be trained and ready for response. When a threshold is exceeded, investigation should start and health personal needs to verify that the information is correct and look for additional cases. The event will be confirmed by lab results and if there is an outbreak, appropriate measures needs to be taken to contain it. In each of these steps, relevant information should be logged in the system, this includes cases and lab results. Outbreaks should be defined in the IDSR system so it is possible to get an easy overview of the current situation of an outbreak or historic data about older outbreaks. When it is declared that an outbreak is over, the health personal should evaluate and improve upon what was done. It can be hard to know that the planned response is sufficient, as there might not be many opportunities to test it.

2.1.6 IDSR Priority Diseases

As the IDSR technical guidelines describes (Nsubuga et al., 2010), the priority diseases that are specified by IDSR can vary from country to country depending on different factors. These factors are the needs of the country, the health system and the epidemiological situation. As resources in less developed countries are often limited, it is encouraged to only have a small list of prioritized diseases, even though the IDSR guidelines specifies 40. Focusing on a small list of diseases will make them more manageable to handle.

Priority diseases, conditions and events for IDSR - 2010		
Epidemic prone diseases	**Diseases targeted for eradication or elimination**	**Other major diseases, events or conditions of public health importance**
Acute hemorrhagic fever syndrome* Anthrax Chikungunya Cholera Dengue Diarrhea with blood (Shigella) Measles Meningococcal meningitis Plague SARI** Typhoid fever Yellow fever *Ebola, Marburg, Rift Valley, Lassa, Crimean Congo, West Nile Fever **National programmes may wish to add Influenza-like illnesses to their priority disease list	Buruli ulcer Dracunculiasis Leprosy Lymphatic filariasis Neonatal tetanus Noma Onchocerciasis Poliomyelitis* *Disease specified by IHR (2005) for immediate notification	Acute viral hepatitis Adverse events following immunization (AEFI) Diabetes mellitus Diarrhea with dehydration less than 5 years of age HIV/AIDS (new cases) Hypertension Injuries (Road traffic Accidents) Malaria Malnutrition in children under 5 years of age Maternal deaths Mental health (Epilepsy) Rabies Severe pneumonia less than 5 years of age STIs Trachoma Trypanosomiasis Tuberculosis
	Diseases or events of international concern	
	Human influenza due to a new subtypel SARS* Smallpox* Any public health event of international or national concern (infectious, zoonotic, food borne, chemical, radio nuclear, or due to unknown condition *Disease specified by IHR (2005) for immediate notification	

Table 2-2: Priority diseases as seen in the IDSR technical guidelines (Nsubuga et al., 2010, p. 18)

2.2 Dashboard Design

An IDSR system will contain a lot of data, which can be complex and intimidating to look at if you look at the raw or aggregated numbers. To make good use of all the data, there is a need for better presentation of it. If data is presented in a way that is easy to understand, both analysts and health workers can make better use of the data.

Dashboards are used quite a lot in many different fields, ranging from information about a stock market to showing air traffic. There are many reasons for dashboard being a good medium for presenting data. A dashboard with good design should show the user all the relevant information at a glance, and it should be easily understandable.

2.2.1 Principles of Visual Perception

Before going into the principles of dashboard design, a short explanation of the principles of visual perception will be presented. These are principles that lays the foundation of how the human mind perceives the visual data presented, and will therefor also apply to dashboard design. It was in 1912 that the Gestalt school of psychology started studying how the mind perceives visual data (Few, 2013). The principles they came up with are called "Gestalt Principles of Visual Perception", and they are still respected today. They cover how the mind ties data together and separates it, as well as how to make some data distinct from the rest. The principles are as described by Few (2013):

The Principle of Proximity describes how the mind perceives data as belonging to the same group when the objects are located close to each other. To separate groups, it is often enough to include some space between them and the mind will perceive them as being independent of each other.

The Principle of Similarity describes how the mind groups objects together by how they look, either by colour, size, shape or orientation.

The Principle of Enclosure is how the mind group objects by enclosure. If some object is placed within a bounding box it is perceived as being a group separate from the objects outside the bounding box.

The Principle of Closure is how the mind tends to complete unfinished shapes. If a rectangle is missing a part of one of its sides, so that the rectangle is not complete, the mind still perceives this as a rectangle, not as a line.

The Principle of Continuity explains how the mind groups objects together if it looks like the objects are aligned to continue one another, even though they are not connected.

The Principle of Connection is how the mind perceives objects as part of the same group if they are connected in some way, for example by a

line. The principle of enclosure is stronger than this principle, as the mind will group the objects differently if they are connected, but separated by a bounding box. The principle is stronger than the principles of proximity and similarity.

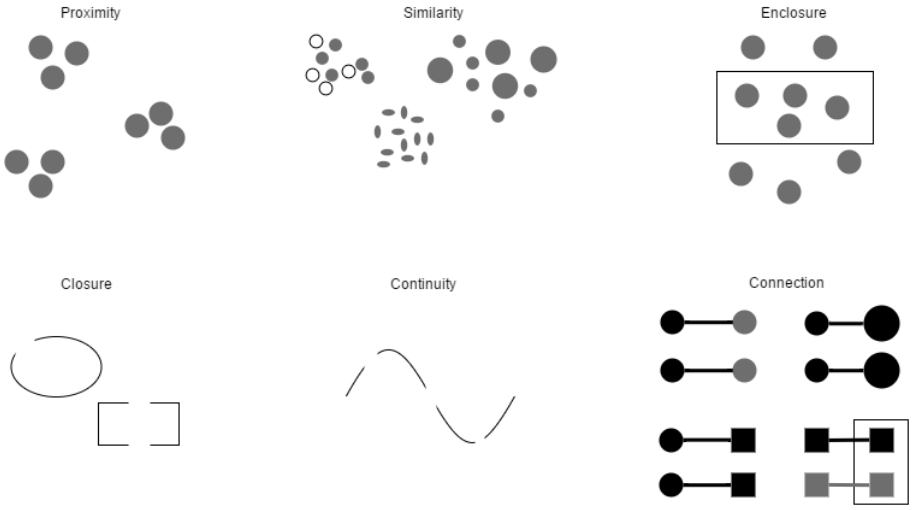


Figure 2-3: Demonstration of the Gestalt principles

2.2.2 Dashboard Design Guidelines

When using a dashboard to display data, it is important that it has a good design and follow good design practices. If not designed right, the dashboard might fail to communicate the data effectively. Being effective at communicating in dashboards means that the user should be able to look at the dashboard and quickly get answers to questions they have without having to process the data themselves. There is no definite number of guidelines of dashboard design, different sources have different number of guidelines, though many of them cover the same points. The format of this section for the guidelines is as follow: first, the guideline is presented in a paragraph, then some follow up information from the sources are presented.

2.2.2.1 The guidelines

Target Audience

A dashboard is usually designed for someone else than the one designing it, keep the user in mind. Will many people view and understand the same dashboard or does it need to be customized to the individual user? Do not assume that the user understands something the same way as you do, base the design on feedback from the user.

> *It was so invaluable to observe hands-on how the dashboard was used and any usability issues that cropped up (not*

everyone knows what a hamburger icon means! labels labels labels!) – Ally Long, UX Designer (eHealth Africa, n.d.)

This is a very important guideline that multiple sources bring up (Borden, 2015; Few, 2013; Mellon Training, 2016; Monsey & Sochan, n.d.; O'Sullivan, 2016; Salesforce, 2013; Schooley, Hilton, Abed, Lee, & Horan, 2011); a dashboard needs to be customized to the person or group that will be using it. Some dashboards might allow the user to customize it themselves. It really depends on the use case if this is a good solution, most often it is better to listen to what the user needs and then act on that instead of letting the users do what they want. Salesforce (2013) mentions that designing dashboards is an iterative process; design the dashboard, put it out, get feedback and then improve it. Schooley et al. (2011) brings up a very valid point: the users are the ones that decides if the system will be used. This guideline is not exclusive for dashboards, it is important in general for design.

Screen Boundaries

A dashboard should be contained within one screen with all the displayed data visible at the same time, with no scrolling required. A user should be able to glance over the dashboard and get a full overview of the situation.

If content is hidden the user might think that the hidden data is not important. It will also be harder to compare between the displayed data if the user needs to scroll between them. Data can be fragmented into multiple dashboards and when doing this it is important to not separate data that is meant to be viewed together. Encountering these problems might often be due to the user wanting more information than what is needed. The dashboard should only contain the essential data that is needed for analysis.

Though Few (2013), Mellon Training (2016) and Lechner and Fruhling (2014) talk about screen boundaries in a general sense, Taylor (2016) and Kwapien (2016) also explicitly mentions smaller screens, like smartphones. The term “mobile first” is something to keep in mind when designing, because even in the developing countries smartphones are used a lot because of how cheap they have become. The use of smartphones will only increase. It is possible to keep the dashboard within the screen boundaries on a smartphone, it depends on the content that will be presented and how it is presented, as demonstrated in Figure 2-4 and Figure 2-5. The guideline will still apply, but with exceptions when it comes to smaller screens. The alternative is to not have the dashboard on smaller screens, which is not a good alternative. As Salesforce (2013) describes, the dashboard should be able to be viewed on a mobile smartphone or tablet and still let the user do everything they can do from the desktop dashboard.

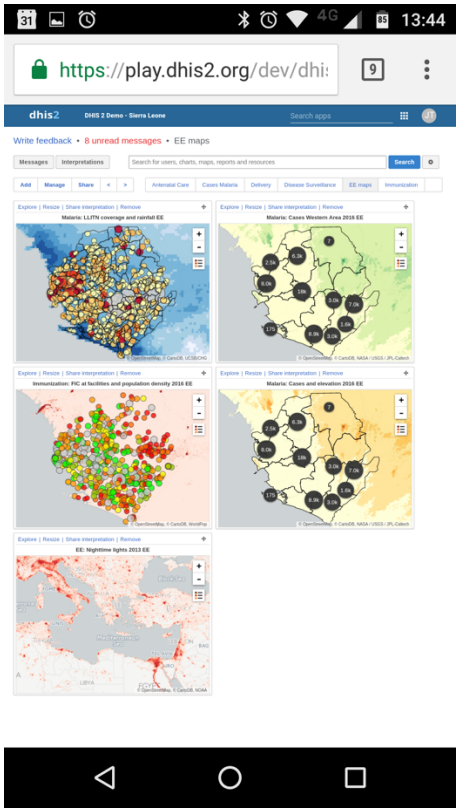


Figure 2-4: DHIS2 desktop view of a DHIS2 dashboard on a smartphone

Though the dashboard Figure 2-4 shows is a DHIS2 desktop dashboard viewed on a mobile screen, it has responsive design[2] so it will fit the screen on the phone. The problem here is that the user needs to zoom to really analyse the graphs or maps. All the user created dashboards in DHIS2 can exceed the screen boundaries, this is due to the customisability that lets the user put as much as they want on the dashboard, this will be discussed later. The next figure shows the dashboard for the Fitbit[3] Android application, it doesn't demonstrate how graphs will look on the dashboard on a small screen, but it shows that a user can get a quick overview of relevant data.

[2] https://en.wikipedia.org/wiki/Responsive_web_design

[3] https://www.fitbit.com/no

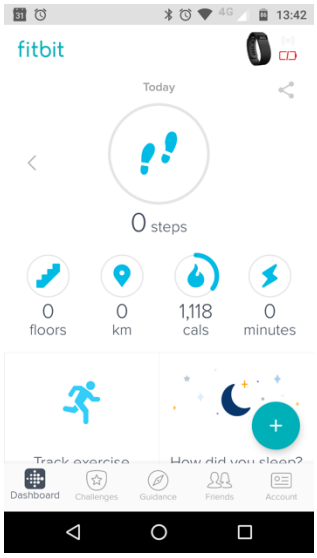


Figure 2-5: A dashboard designed for a small screen. It gives an overview of the information that the user wants.

Display Essential Data

A dashboard should only contain the essential data for analysis and decision making, this entails a few things. Do not display unnecessary precision in the numbers. Do not make the user do calculations themselves, the dashboard is meant to reduce the workload of processing the data and should make it faster to analyse the data. Only display the minimum dataset needed for the analysis, users might want more data than they need and that will only clutter the dashboard.

This guideline is very important in dashboards, where you want only the most essential information to be displayed compared to a report where you can include a lot of extra information. Levy (2017) suggest following the five-second rule when designing the dashboard. The user should need no more than five seconds to find what he is looking for. Further, he puts a number to how many visual objects should at maximum be displayed on the dashboard: there should be no more than 5-9 object visible in the dashboard at a time to avoid cluttering and halting the effectiveness of the analysis. The dashboard should provide easy access to more detailed data so the users can drill down into the details if needed (Borden, 2015; Cheng et al., 2011; Few, 2013; Lechner & Fruhling, 2014; Mellon Training, 2016; Morgan, Branstetter, Lionetti, Richardson, & Chang, 2008; Schooley et al., 2011; Toddenroth, Sivagnanasundaram, Prokosch, & Ganslandt, 2016). There are different ways to solve this depending on how extensive it should be, one could separate the details into another dashboard or have a popup that shows the details when clicking on an item.

Data Needs Context

The displayed data also needs to be viewed in a context that needs to be supplied. A sales number will not mean much if there is no indication if it is good or bad, give the data some context by displaying data for bad, average and good sales number.

Without proper context, the user will not know if the data he is looking at is good or bad, and if any action needs to be taken (Kwapien, 2016). Showing the user target values or historic data are some ways to give context to the data (Kwapien, 2016; Lechner & Fruhling, 2014). Schooley et al. (2011) created a dashboard for displaying valuable data about the patient during emergencies, here they found that a picture of the accident scene provided great context for each case. Few (2013) points out that it is not enough to use a colour to indicate the status of the data shown, there needs to be defined values so the user can see how far they are from the goal. Figure 2-6 gives an example of how little information is provided by only displaying a colour for the status of the data and Figure 2-7 shows a better example of context.

Figure 2-6: The colours of the needles indicates if the number is good or bad, but it still does not give the measure a meaningful context

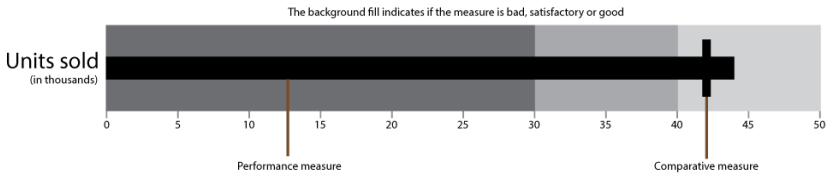


Figure 2-7: The bullet graph was designed by Stephen Few specifically for dashboards (Few, 2013, p. 191)

Data Layout

The most important data should be placed at the top of the dashboard, more specifically the top-left. This is due to the way most cultures read,

the eyes will usually drift to the top left corner automatically. If some data needs to be compared, they should be placed close to each other.

Design the dashboard with the human visual perceptions in mind, think about what should be grouped together and place the most important data in the top left (Cheng et al., 2011; Few, 2013; Kwapien, 2016; Mellon Training, 2016; Monsey & Sochan, n.d.). Another way to look at it, like Levy (2017) does, is to put it in the context of the inverted pyramid[4], which is a writing style often used in journalism. The top information is the most newsworthy, while the middle information is important details, and lastly the bottom contains more general information. This guideline is generally important for design and is not exclusive to dashboards.

Choosing the Display Media

For the presented data to be effective, it needs to be display using the correct media, be it either by text, graph or map. Do not use different display media just to create variety, use the media that best conveys the data to the user.

A common theme when talking about choosing the wrong display media is to use pie charts as an example (Few, 2013; Kwapien, 2016). These are too commonly used to present data, but it is often hard for the user to accurately compare the sizes, and if the size differences are huge, the small piece gives no meaningful information (Kwapien, 2016). Line charts can be used to display patterns over time, but should not be used if the elements are not connected, a bar graph could be more useful here. It might not always be easy to find the correct chart to display the data and sometimes the users might not even agree, but it is important to consider it carefully.

Display Media Design

The display media itself needs to have a good design to most effectively convey the data to the user. It should adhere to standards for labels and icons so that it looks familiar to the users.

One of the important things in a dashboard is to reduce clutter, this is also important for the individual display medias. In the book "The Visual Display of Quantitative Information" from 1983, Edward Tufte[5] defined

[4] https://en.wikipedia.org/wiki/Inverted_pyramid_(journalism)

[5] https://www.edwardtufte.com

this as the data-ink ratio[6] (Few, 2013), which is meant to show the proportion of ink used for data compared to total ink used. Few (2013) dubbed it the data-pixel ratio as it still holds up today and is relevant for dashboards. The point is that as much as possible of the graph should display relevant data, though within reason. Some notable things to not include are 3D effects, shadows, gridlines in the bar graph and unnecessary gradient effects that does not add to the data (Few, 2013; Kwapien, 2016; Mellon Training, 2016). To create a better experience for the users, the charts should have the same look and feel across platforms (Lechner & Fruhling, 2014; Schooley et al., 2011).

Highlight the Important Information

If there is something in the dashboard that needs the user's attention right away, it should be highlighted to stand out from the rest of the dashboard.

This might seem to contradict the guideline that says only important data should be on the dashboard, but Few (2013) divides the data into two categories. The first is data that is always important and the second is data that is important in the moment. If some data must get the users attention right away, highlighting the data is an effective way to pull the users attention towards it. Highlighting data should be used sparingly though, because it might lose its purpose if overused (Asif, 2016). Highlighting important information is an effective way to pull the users attention and this is not exclusive in dashboard design.

Colour Palette

Stick to a few colours and think about the colours you choose. Contrasting or warmer colours often draws the user's attention. The user might perceive that data with similar colours in different parts of the dashboard are related. The traffic light colours are often used to give an indication if something is good or bad, but going back to the guideline of knowing the target audience, maybe a user is colour blind and then that might not be the best way to give context to the data.

Kwapien (2016) suggest choosing 2-3 colours and sticking to them and then use gradients of the same colour if it is needed to convey useful information. Stay consistent to create a better user experience, the point of this is so that the user can grasp the information on the dashboard as fast as possible. As for which colours to choose is up to the designer, some wants to use the organisations brand colour. Working in the field, eHealth Africa (2016) notes that the dashboard might also be printed

[6] http://www.infovis-wiki.net/index.php/Data-Ink_Ratio

out for training lessons, and the colours should therefore not only be good on screens, but also on paper.

Make the Dashboard Attractive

The data itself should be one of the main factors to make the dashboard be used, but if it is not presented in a good way it will not be used. Though this guideline repeats a lot of the others, it needs to be explicitly stated: Keep the dashboard clean and neat looking. Choose a nice-looking theme to build the dashboard around, for example flat or material design.

> *"Be fun and creative. This point seems to stand in contradiction to what we have already said. However, when we stressed that the colors should be subdued and the layout well-thought-out, we didn't mean that your dashboard should look boring. On the contrary, we want you to let go of Power Point style presentations from the 90s. The modern dashboard is minimalist and clean. Flat design is really trendy nowadays." (Kwapien, 2016)*

Few (2013) points out many ways to make the dashboard aesthetically pleasing, some of which has been covered in the earlier guidelines. These includes colour choice, high-resolution on text and images, content layout and font type.

Time and Updates

The dashboard should indicate the time, so that the user knows when the data is from. The frequency of the dashboard updates should also be considered.

There is no need for real time updates of the dashboard if the data doesn't update in real time (Borden, 2015; Few, 2013; Kwapien, 2016). The update frequency should be known to the user if it is very short and the user should be able to halt updates if needed (Few, 2013).

Summary

Many of the guidelines build upon each other. Monsey and Sochan (n.d.) mentions making interactivity clear to the user as a guideline, but ultimately that is just a part of designing the dashboard and the display media well. The following table shows a summary of the dashboard guidelines that will help in creating a dashboard that will present the data in a meaningful way to the user, without distractions and cluttering.

Guideline	Description
Target Audience	Keep the user in mind when desgining.
Screen Boundaries	Keep the dashboard components within the screen boundaries. Exception may be applied for small screens.
Display Essential Data	Only display data essential to the decsision making. Do not display nice-to-have data.
Data Needs Context	Give context to the data by displaying target values and comparison data.
Data Layout	Data that will be compared to each other should be located near each other and the most important information should be at the top of the dashboard.
Choosing the Display Media	When displaying data, choose the display media that best conveys the information to the user.
Display Media Design	The display media should be well designed, with minimum amount of non-data pixels. It should be within standard convention so the users are immediately familiar with it.
Highlight the Important Information	Highlight the important data that should capture the users attention.
Colour Palette	Stick to a few colours in the whole dashboard. Warm or contrast colours can be used to capture the users attention. Depending on the project, consider if colours should be adjusted for colour blindness.
Make the Dashboard Attractive	The dashboard should look aesthetically pleasing.
Time and Updates	Indicate when the data is from and concider how often the data should be updated.

Table 2-3: General dashboard design guidelines

2.2.3 Choosing Display Media

Selecting the best display media comes down to choosing the media that best communicates the given data. It should also be able to scale to different screen sizes while still retaining the usefulness to communicate the data. There are a lot of graphs to choose from and many of them will not be a good choice for a dashboard. This is due to them being confusing to the users or that other graphs communicate the data better. First, a list of graphs that can be used in dashboards and why will be presented, then a list of graphs that should not be used and why. The reason for including a list of graphs that should not be used is because some of these are popular choices when displaying data, but there are often better alternatives. The following section presents graphs that Few (2013) suggest being or not being used for dashboards and why. These are just short descriptions, followed by an illustration of the described

graphs; for an easier comparison of which to choose there are better alternatives: (Abela, 2009; Few, 2016).

2.2.3.1 Good Alternatives

Bullet Graph

This graph was designed specifically for dashboards (Few, 2013), to show data with context in a small space. It is meant to replace the gauge graphs due to the lack of information these gives. This graph is designed to display a single instance of a measure, unlike for example bar graphs where multiple instances are shown.

Bar Graph

Bar graphs are easy to read, they are used to display measures of data for discrete item in categories. It is usually easy for the user to quickly see the differences in measures, that is if there are not too little differences in the measures. They are better at displaying parts of a whole, than the popular pie charts, as it is easier to compare the values. It is possible to use stacked bars to display data as a whole, but this might also make it harder to compare the data.

Dot Plot

When you have a bar chart where the data measures are not very varied it can be hard to compare them. Starting the Y-axis on a higher number than zero is a way to remedy this, but doing so with a bar chart might be misleading and confusing. The height of the bars does not accurately represent the measures anymore, so dot plots can be used instead as they show value based on position and not based on height (Few, 2013). Dot plots can even be a better alternative to bar charts in a dashboard, as it does not have as much visual weight that comes with a bar chart.

Line Graph

This graph should be used when displaying the shape of change over time. The Y-axis does not have to start at zero, it is better to fill the graph with data instead of having a lot of white space.

Sparkline

This is a small graph that is only meant to show trending direction: is the measures going up or down over time. Since it does not show any details it does not require much space.

Box Plot

This graph can show a lot of data in one graph. It displays multiple measures and their centre, spread and shapes for easy comparison (Few, 2013).

Scatter Plot

Used to display correlations between two measures. It is common to use a trend line to emphasise the correlation between the measured values.

Spatial Map

This can be used when the data is tied to a physical location, but it should only be used if it is meaningful when looking at a dashboard.

Heat Map

This can either be a map or a matrix, but the bottom line is to represent the data in variation in colour, often from good to bad.

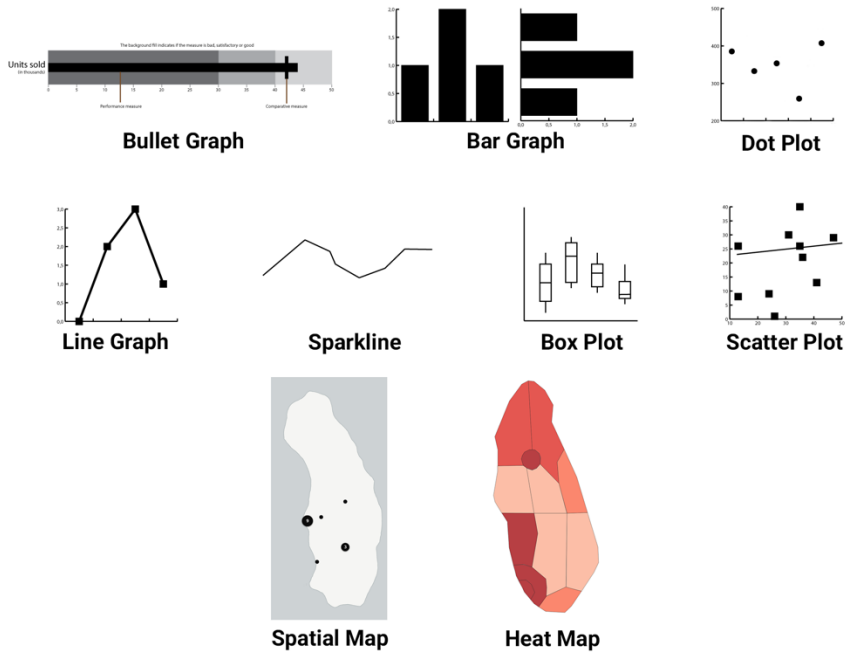


Figure 2-8: Graphs that are good options to use in dashboards

2.2.3.2 Bad Alternatives

Pie Chart

This chart is designed to show parts of a whole, but it does not communicate the data well. It is hard for users to compare the pieces of the pie, and a bar chart can communicate this data better.

Area Graphs

Charts that encodes the data values in 2D space is often hard to interpret by the users, and some might even hide data. These graphs include pie chart.

Radar Graph

This graph is difficult to read and to compare values and is therefore not useful in a dashboard where information should be communicated quick and concise. They are a more confusing version of the line graph arranged in a circle.

Funnel Chart

It is meant to display the reduction of data as it flows through a series of stages. It displays each part as a percentage of the whole and is most commonly used in sales.

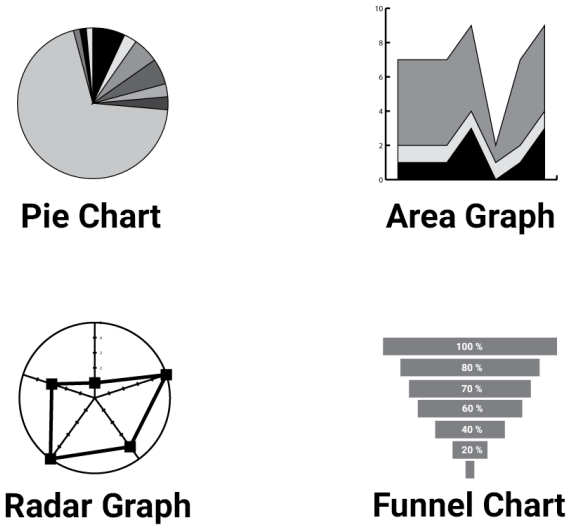


Figure 2-9: Graphs that should not be used in a dashboard

2.3 Data Visualization in Public Health

Public health is a broad field, which means creating one solution that fits all is hard or even impossible. As Sedig and Ola (2014) describes, the public health workforce can be very diverse and activities varies by groups (epidemiologists, nutritionists etc.) and levels (state, local etc.) and what they do. Further, they put the "big data"[7] label on public health data, which is a term used for when there is so much information it is hard to capture, store and analyse the data. The challenges of "big data" are not exclusive to public health, but the progress in commercial fields is further ahead when it comes to visual analytics tools. Sedig and Ola

[7] https://www.sas.com/en_us/insights/big-data/what-is-big-data.html

(2014) also describe that the best solution to visualizing the information is to make it interactive so the user can filter, compare and drill down in the information.

Foldy et al. (2004) did a pilot project in surveillance and data use for bioterrorism preparedness, which gave them good results for data collection. The hospitals that participated the project sent a report each day that would contain information that is helpful for bio surveillance and the analytical data would be displayed in a near real time dashboard. The problem with the pilot was that since no disease outbreaks were detected during the four-week test period, they cannot determine if such a system would help decrease mortality and morbidity, as well as reduce the cost that a bioterrorist event would require.

Cheng et al. (2011) did a pilot project for influenza surveillance. The objective was to create a generic framework for data capture and analysis. This was done by creating a specific dashboard for influenza surveillance in Hong Kong. The system handles multiple data streams and display the analytical data in a dashboard. They designed the dashboard with design guidelines in mind. The article describes that research data dissemination is lacking and suggests it might be due to that the medical science field has been seen as unrelated to communication and graphical design.

There are more research projects that could be mentioned in detail, but instead I summarize: There is a lot to learn from the articles in how they choose to tackle their projects, even though the design guidelines are not explicitly mentioned, elements of them are there and they provide insight in how other projects in public health were tackled (Kang, 2011; Shneiderman, Plaisant, & Hesse, 2013; Sopan et al., 2012).

2.4 DHIS2 Software

DHIS2 is a Health Management Information System. It can be used to analyse public health data as it can aggregate the data and present it in various ways, it is meant to be very flexible for the users and should require little technical skills. DHIS2 has become a very well established software after many years of development, which makes it a good candidate to be strengthened to an IDSR platform, instead of creating new software.

2.4.1 DHIS2 History

The Health Information System Programme (HISP) started working on the first version of DHIS2, then called DHIS, in 1994, to help rebuild the health care system in South Africa after the apartheid regime (J. Braa & Sahay, 2013). The first version of DHIS was a database application built on Microsoft Office Access 97/2000, which was a well-known

technology for potential users at the time. As J. Braa and Sahay (2013) describes it was open source and was using participatory design for interacting, testing and collaborating with the users, so that DHIS was to be in line with what was needed. Users at all levels were encouraged to communicate with the developers to tell them what they needed. This could be very time consuming, as not all users know what they want or need, so the developers often had to guide them. The user requests stabilized after the first phase of very rapid prototyping, this made it easier to have controlled updates instead of having new weekly or daily builds. The user base increased and by 2001 DHIS was in full use in all South Africa.

In 2004, it was decided that a new revised and international version of DHIS should be made, DHIS1.4, due to the first version having an increasingly messy architecture. This version was also built upon Microsoft Access technology, which wasn't that great since DHIS was open source, but it was dependent on a proprietary stack. As the project grew, more developers were needed, but code sharing was hard in the current system. This prompted the development of DHIS2, which began in 2004 under the leadership of the University of Oslo.

When selecting technology for the new version, it was decided to make it Java based. This was bleeding edge at the time, which resulted in some hardships when re-implementing the system as a web application. The new first real implementation of DHIS2 first came out in 2006 after much hard work from the developers, it was released in Kerala, India (J. Braa & Sahay, 2013).

Code sharing was done through the Launchpad[8] platform, which made it easier for developers around to the globe to work on the same project, instead of forking it. Forking the project was one of the problems in DHIS1.4, were one developer might create something that would make his implementation of DHIS1.4 be incompatible with new updates from the main DHIS1.4. DHIS2 recently released version 26 and the source code has been moved to Github[9], as this is a more modern platform than Launchpad.

2.4.2 DHIS2 Structure

If DHIS2 is to be strengthened into an IDSR platform, it is important to understand how data is structured in the system. Understanding the underlying structure of DHIS2 will be important when moving into

[8] https://launchpad.net/

[9] https://github.com/

IDSR territory. This will help when trying to implement IDSR functionality to see if things can be reused or if completely new functionality needs to be implemented. The following information is an overview over the structure as explained in the DHIS2 implementer guide (DHIS2 Documentation Team, 2017a) and user guide (DHIS2 Documentation Team, 2017b).

2.4.2.1 Organizational Units

Location data in DHIS2 is represented as an organizational unit. That is where the data was registered, for example at a health facility. The organizational units are represented in a hierarchy that reflects the real health administrative structure and levels. This structure is useful when aggregating data, say if a district wants to find how many cases of a disease was registered for a specific month, they would aggregate the data registered by its child organizational units.

2.4.2.2 Data Elements

This represents the data that will be collected or analysed, it describes the data, therefor it needs a descriptive self-explanatory name. This is not the data itself, but all data in DHIS2 is linked to a data element.

2.4.2.3 Data Sets

Data that is collected together in DHIS2 is organised in data sets. A data set is a group data elements that will be collected and it has a frequency of how often the data should be collected.

2.4.2.4 Indicators

An indicator is used for analysing data. Creating good indicators will help with comparing data, for example a place with higher population will have higher numbers of registered cases compared to a place with lower population, but they can be compared if percentage is calculated.

2.4.2.5 Programs

It is possible to set up custom programs in DHIS2. A program defines an event; this means that the program defines the data to be registered for an event. An example would be if an outbreak program was defined, users could choose that program to register an outbreak event. The program has attributes that the user fills in.

2.4.2.6 Data Entry

There are multiple ways to enter data in to DHIS2. This is more of a general explanation of the methods; this is to understand how the data is structured in the system and won't cover mobile reporting. The data

from mobile reporting will be structured the same way when it gets into the DHIS2 system.

The first method is registering aggregated data. The entry forms here are often a direct conversion from paper based forms to digital forms. This is the classic way of entering data and it is not possible to enter single events here, only aggregated data on a daily or less frequent basis. This method of reporting is defined by creating a dataset. Even though the other ways to enter data is better, aggregate data entry is still needed. Not every facility or even district might have the required tools or resources to use event or tracker capture.

Event capture can be used to register immediate single events, as it does not have the limitation of registering fixed periods. Events are defined by a program.

Tracker capture can be used to register both multiple or a single event, and it is a more advanced version of event capture. A tracked event is tied to a tracked entity, which for example could be a person. This means that the event can have multiple program stages so that the case or person can be followed up.

2.4.2.7 Validation Rules

These are expressions for checking if data is correct, this is done by choosing a left and a right value and comparing them. An example would be that the number of HIV tests conducted cannot be lower than the number of positive results.

2.4.2.8 Analytics

There can be a lot of data in a DHIS2 instance. It is possible to do queries for the raw data, but this can be quite slow. DHIS2 can be set up to run analytics, which will create additional tables in the database. These new tables are structured in a way that makes it faster to query for aggregated data.

2.4.2.9 Web API

With the Web API that DHIS2 provides, developers can create third-party applications that can access the data in DHIS2 without having to be integrated into the core. This means that one does not need to be familiar with the Java-stack that DHIS2 is built upon to develop software for it. External applications can authenticate with the web API and both save and read data from DHIS2. It is also possible to structure an application as an Open Web App[10] and upload it to DHIS2, it will then

[10] https://wiki.openmrs.org/display/docs/Open+Web+Apps+Module

show up in the application finder in DHIS2 and can be accessed by all the users of that DHIS2 instance.

2.5 Uganda

Uganda is a country that is plagued with many challenges when it comes to the public health. The African Health Observatory and the WHOs Regional Office of Africa reports (African Health Observatory, 2016) that in 2012 Uganda had a population of a little over 35 million people, and that between communicable, non-communicable and injury related deaths, 68% of deaths were due to the communicable diseases. The population is growing fast and in 2015 the population were estimated to be over 39 million people; this creates a very unbalanced age structure. Furthermore, they report that in 2013 the population that is under 15 years old is 48,4% of the total population. Even though Uganda still has a lot of challenges, the report shows that the life expectancy at birth has improved by going from the age of 47 years in 2000 to 62 years in 2015. Though improvements have been made, there are still a lot that needs to be better, the report shows that few of the Millennial Development Goals[11] (MDG) set for 2015 has been met.

2.5.1 Health System Structure

The health system structure in Uganda is referral based, which means that if the health workers at the lowest level cannot help the patient, he is referred to another facility that can treat him. As described by Kavuma (2009), the lowest level in Uganda's Health system is not called CHW, but instead they are called Village Health Team (VHT). These are volunteers that are chosen by the communities to support them in the rural areas. They do not get paid, but might get some benefits that will help them in doing their job, for example one might get a bicycle for easier transportation. They are the first line of health care when it comes to helping the community. Every community should have a VHT, but this is not always the case, and some VHT might not even have basic medicine. The VHT refers patients to the higher levels for treatments they cannot handle. The higher levels serve more people and is both more educated and has more resources to treat the patients, the levels are level II, III and IV.

Each district has a District Surveillance Officer (DSO) that communicates with the health facilities in his district. In some districts, the DSO is the one who fills in the health facilities reports into DHIS2. This was the case in the district I was visiting, the DSO would use a tablet

[11] http://www.undp.org/content/undp/en/home/sdgoverview/mdg_goals.html

to report all the data for each facility. The health facilities do weekly reporting, but if there would be a case of an immediate reportable disease, the DSO would be contacted immediately through SMS or by phone using a toll-free service.

At the highest-level, Uganda has the MoH and that is where decision making is done. For better disaster detection and response, the MoH established an Emergency Operation Centre.

2.5.2 Uganda's Emergency Operation Centre

In 2014, Uganda's EOC was established (United Nations Development Programme, 2014). It is located at the opposite side of the road from the MoH in Kampala. This is a hub that is manned 24 hours every day, and their job is monitoring for early disaster detection and coordinating emergency response. They rely on DHIS2, the media and contacts in the field for detecting diseases outbreaks.

2.5.3 mTrac and DHIS2

As Blaschke (2012) describes, Uganda had too many eHealth initiatives, which led to the MoH putting a stop to it in 2011. There had been over 100 mHealth projects that had been started in the previous years, and due to fragmentation and poor communication between the projects the MoH had to stop it. mTrac was one of the initiatives that was approved by MoH after the ban, this was due to following reasons; mTrac did not require high resource cost, it had a clear plan for national scale up, and it was government led.

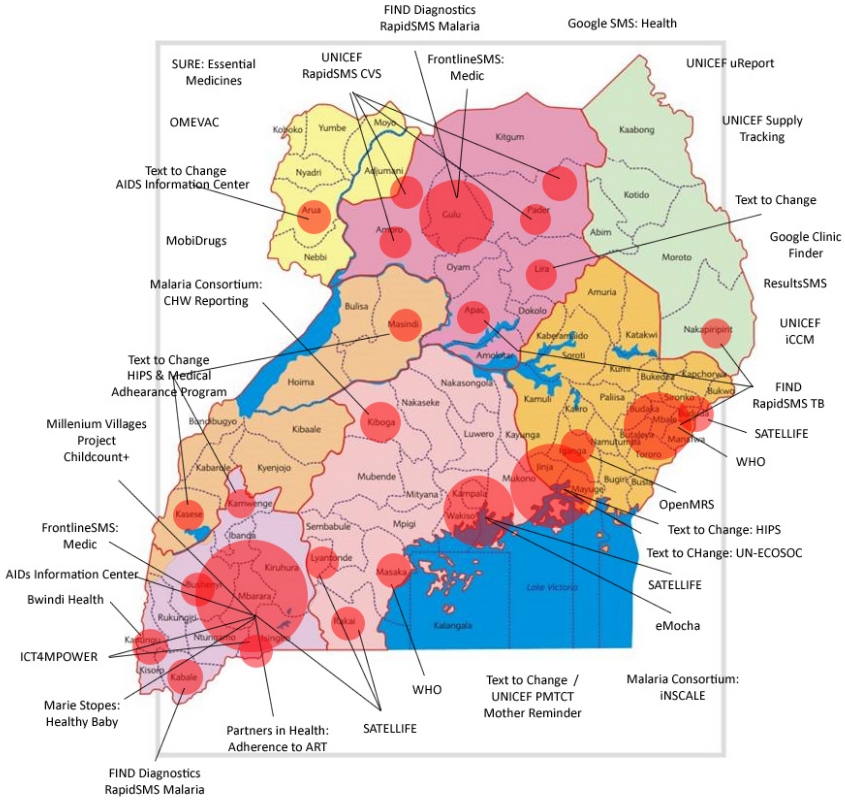


Figure 2-10: Map of mHealth pilots in Uganda (Blaschke, 2010 - License: https://creativecommons.org/licenses/by-nc/2.0/)

DHIS2 is the national HMIS in Uganda, but even though DHIS2 has support for SMS services, mTrac is still used. As RapidPro (n.d.) describes, mTrac is an open source project developed by UNICEF[12], it launched in Uganda in 2011 and is used for SMS reporting. It was initially developed to be used in disease surveillance, and it replaced the paper based form for weekly notifiable disease reporting. Since 2013, mTrac is being used nationwide in Uganda and it has come a long way since then. It is now also being used to report on medicine stocks at the local facilities, malaria cases, as well as providing anonymous communication channels for letting people write complaints or concerns about the health services provided. It has also helped with communicating to the health workers during outbreaks, as the MoH can send messages them in the field.

[12] https://github.com/unicefuganda/mtrack

Further, RapidPro (n.d.) describes mTrac as a success, as it has helped with early disease outbreak detection and reduced medicine stock outs for facilities. When reporting to mTrac there is a defined structure for the SMS, if the user has done something wrong they will get an error message back. If there are no errors, the user will receive a message that asks them to confirm that the data they entered is correct. The information entered in to mTrac is also audited at the district level, by district health offices or other national stakeholders. If there are discrepancies or unusual reports, the health workers can be contacted through mTrac to verify that the reports are accurate. When a district approves the entered data as legit, the data is sent to the national HMIS. This gives better data quality for the data in DHIS2, which is where the MoH will look at the data.

2.5.4 HISP Uganda's Proposed IDSR System in DHIS2

HISP Uganda had a proposed IDSR system to be implemented into DHIS2. This will be briefly explained here, but appendix A contains more details. The proposed system was a result that came from already having implemented a similar system in Rwanda, which was done by HISP Uganda.

The first component for the proposed system is case based tracking of immediate notifiable diseases. This should only require the minimum dataset that is necessary to use in disease outbreak analysation and decision making. When a case is registered into the system it has three stages that can be updated with new events: lab request, case monitoring and lab result.

The second component is outbreak management. This was so that when there is an outbreak it can be registered in DHIS2 and then analysts can look at data for that outbreak. This was meant to be generated by DHIS2 if number of registered cases reached a threshold, but due to political reasons it should not be called an outbreak. DHIS2 can generate alerts for outbreaks, but only the MoH can declare an outbreak. That is why there needs to be an outbreak component and an alert component.

3. METHOD

HISP UiOs way of working toward their goal of supporting and strengthening countries health systems, as well as making them sustainable for the countries to improve the health services they deliver, is based on action research. This thesis is based on qualitative research done through case studies, but leverages connections that HISP UiO has built up in their "network of actions". A network of actions means that their strength is built through collaboration and knowledge sharing. Each part in the network of actions might be weak in different areas, but through collaboration with the rest of the network they possess greater capacity (K. Braa & Nielsen, 2015).

First, case study and canonical action research will be described, followed by why case study was used in this research. Further, the field trip to Uganda will be described and the data sources. Lastly, the research methods used during the research will be described.

3.1 Case Study

As an empirical research method, a case study is, according to Yin (2002), "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." (cited by Easterbrook, Singer, Storey, and Damian (2008, p. 294)). When conducting a case study, it is important to specify the research question(s) that the study intends to look at. Observation and interviews are an important part of data collection in case studies and the researcher can either be directly involved with the case or be an outsider studying it. Easterbrook et al. (2008) describes two ways to conduct a case study: exploratory and confirmatory. The former is used to

investigate and form new theories about a case, while the latter is for confirming theories. Further, they describe a case study will focus on a "unit of analysis". The unit will depend on the broadness of the case, but the unit of analysis could be a person, a team, a project etc.

Stake (2005) puts case studies into three categories: intrinsic, instrumental and multiple case studies. He defines that in an intrinsic case, it is the case itself that is the interesting thing to look at. The result of an intrinsic case is not meant to be used as a part in a larger study. An Instrumental case is the opposite, where the case study is a means to understand a broader picture. The case is still looked at in depth, but it is only a supportive role to understand something bigger. Lastly, when you have multiple case studies, it is meant to look at a common phenomenon between the cases, therefore each case here is an instrumental case.

3.2 Canonical Action Research

As described by Davidson, Martinsons, and Kock (2004), there are many types of action research, but what makes Canonical Action Research (CAR) a good research method for Information Systems is its focus on collaboration and iterations to improve something and to gain more knowledge of it at the same time. The researcher work together with the "client" to identify and solve a problem. CAR can be compared to agile software development[13], where a project is done in iteration, with each iteration gradually getting closer to solving the problem. In CAR, iterations are called cycles, in each cycle there are five stages: diagnosing, action planning, action taking, evaluation and reflection. The benefit of doing things in multiple cycles is that it is easier for the researcher to adapt to unforeseeable circumstances and variables that might happen in a real-life setting. Doing this type of research often involves being part of a larger network or a team that is working on the same problem.

3.3 Method Used in This Thesis

Though a case study and action research can use similar methods for researching, the line between them is how much interaction is done with the subject of study (Avison, Lau, Myers, & Nielsen, 1999). In action research, the researcher is more directly involved with the subject and the result of the research is not only knowledge but also change. During the research for this thesis, a prototype for an EOC dashboard was developed. This was to understand what the users of the dashboard

[13] https://www.agilealliance.org/agile101/

needs for evidence based decision making, whereas if this research had been done through action research there would have been more focus on developing a fully working prototype of an EOC dashboard and then possibly improving it in further research cycles. Analysing dashboards in DHIS2 is also a part of the larger context of the case study, which is to see if better designed dashboards can facilitate improved evidence based decision making in developing countries. Case study was chosen as a method to research dashboard design guidelines that can improve the decision making, but to test them in practice could fit better in an action research approach where the guidelines could be tested in practice on a larger user base.

3.4 Field Trip

My research started in an exploratory fashion with a field trip to HISP Uganda and their office is in the capital of Uganda, Kampala. The trip lasted roughly two weeks between 07.11.16 and 18.11.16. The purpose of the trip was to broadly learn more about the domain and related practices of disease surveillance and response and more particular to gather requirements for the EOC dashboard. I also wanted to get to know what HISP Uganda was doing, their way forward and how I potentially could contribute to this.

HISP Uganda presented their vision for the IDSR system, which they will implement in Uganda. Before starting the implementation, the requirements needed to be refined. This meant getting feedback from users. HISP Uganda had already implemented a similar system in Rwanda for tracking patients and lab results in DHIS2. In Rwanda, the citizens have a social security number, which means it is easier to track the cases in the system. The citizens in Uganda does not have a social security number and therefor the system requires case based tracking instead of person based tracking, which could potentially mean duplicated entries if a patient goes to multiple health facilities. The presented system will handle patient and specimen tracking, but only by using the minimum dataset needed. How the collected data should then be presented to the user and be used for decision making were also discussed, but ultimately more information was needed from real users.

A day trip to the city Jinja was conducted, this was both to spread awareness of the IDSR system to health workers in Uganda that were attending a DHIS2 seminar and to gather requirements from a health worker from the EOC. As mentioned, the system should also handle specimen tracking, this sparked a discussion of how extensive this system should be. HISP Uganda was very clear on that the specimen tracking should not be a replacement for a lab system. It will not have the same full functionality as a lab system, rather it should support the analysts and health workers so they can see if the specimen result is

positive and if so, which disease it was confirmed to be. This discussion also included physical tracking of specimen, whereas the EOC would like to have the specimen go through checkpoints on the way to the lab so they always know where the specimen is located. Ideally this should be automated and have as little human interaction as possible to prevent human errors. It would be expensive to create this tracking system and it needs to be discussed further, but that is not in the scope of this thesis. The health worker gave a lot of insight on how things are currently done and why a better system is needed.

Another meeting was held at the Uganda EOC office. The proposed system was once again presented here and HISP Uganda received positive feedback. These were the people that need an EOC dashboard the most, as their job is to monitor the health situation nationally in Uganda based on registered data and other sources to detect disease outbreak and trigger adequate response.

During a trip to a district, the DSO indicated that it would be useful with a monitoring dashboard. Some of the elements in a monitoring dashboard can already be created in the current version of DHIS2, but as the DSO mentioned the health workers usually do not have the know how to set up these dashboards and it would be useful if these were auto generated for IDSR diseases. This made it clear that there are different dashboards that would be useful for IDSR. One for the EOC where they can view alerts and outbreaks on a national level for all districts and facilities, as well as routine data for the sixteen priority diseases. The other one would be for the individual districts for monitoring their district and facilities, as the DSO put it:

> *"Sometimes there can be outbreaks that we don't register, because we don't have a way to quickly analyse the data".*

3.5 Data sources

Field notes

I used field notes during my field trip to Uganda and in the meetings and discussions that were held. Afterwards I went over them again, reflected and filled in more details. The field notes would later be used for prototyping the EOC dashboard and thinking about dashboard design guidelines.

Meetings

Discussion and meetings were held, which were essential for getting data. Most of these meetings were unstructured and more of an open discussion between the parties present. In Uganda, the following meetings contributed to this thesis:

- Meeting with HISP Uganda where the proposed IDSR system was presented. This gave me a more detailed understanding of what data would be collected and how the data was set up in DHIS2 to later be consumed by the EOC dashboard.
- Meeting in Jinja with EOC health workers. How they work, their challenges and needs were explained and even witnessed, which gave me a deeper understanding why the system needs to be improved.
- At the EOC headquarters the proposed IDSR system was presented to the EOC workers. The EOC daily PowerPoint slides (appendix B) were discussed, which contains information that the EOC would like to use DHIS2 for instead. The slides had multiple data sources so not everything will be possible in DHIS2.
- Another brief meeting was held with one of the health workers in EOC. This helped me clarify some things for the EOC dashboard, and contact information was exchanged for future communication.

In Norway, the following meetings contributed to this thesis:

- Initial Skype meeting with HISP Uganda to be briefed on the IDSR system and to discuss a field trip.
- Several small unplanned meetings with the lead implementation coordinator for DHIS2 were held. This helped with understanding how DHIS2 works, which in turn made it easier later to implement a prototype dashboard.
- A meeting with a student with expertise in user interface design was held to discuss the dashboard design guidelines.
- I attended a DHIS2 expert meeting in Oslo. The attendees here were developers, implementers and users of DHIS2. This meeting gave me a lot of information about requested and upcoming features for DHIS2, which was very informative and useful in relation to data usage and dashboard design.

Additional meetings were held, but the ones I've mentioned above are the ones that provided data for this thesis.

Email

This has been the main communication tool after the initial field trip to Uganda. Requirements and system implementation has been discussed here between the DHIS2 developers and the implementers at HISP Uganda, as well as feedback for the prototype EOC dashboard. Around 75 emails have been exchanged related to the IDSR project.

Books and Earlier Research

As IDSR is a relatively new domain for HISP UiO, the IDSR technical guidelines (Nsubuga et al., 2010) were used to gain more knowledge about it. Dashboard design was something I had not thought a lot about before going into this thesis, therefore multiple sources were used to get a better understanding of what is good dashboard design: The book Information Dashboard Design (Few, 2013) was a good source for guidelines for creating dashboard, as were blog posts from people and companies in the industry of creating dashboards. Earlier research in dashboards for public health were also used to learn from other projects.

3.6 The Research Process

My research aims to look at dashboard design guidelines in the context of public health dashboards in developing countries. My motivation for doings this is that guidelines for creating dashboard potentially can lead to more relevant dashboards, increased data usage, and improved decisions. The research process can be summarized into a few stages:

1. Learning about IDSR and gathering requirements.
2. Researching dashboard design guidelines and understanding the structure of DHIS2.
3. Testing the use of dashboard design guidelines in practice by prototyping an EOC dashboard for IDSR in DHIS2.
4. Analysing DHIS2 dashboards to test the guidelines and see if they fit for user created dashboards.

IDSR is a relatively new territory for HISP UiO. I therefor spent a lot of time on learning the details of this domain, the involved business processes and informational needs. Researching guidelines for dashboard design was done through exploring earlier research, prototyping and collecting feedback, looking at bad and good dashboards and by analysing the DHIS2 standard dashboard. A DHIS2 expert meeting was held, which gave good insight into how users use the dashboards and what requirements they have. I describe these different activities more in detail in the further.

Gathering Requirements and Understanding the User Needs

DHIS2 is strong on data input and supports the data collection part of IDSR well. But even though DHIS2 also has flexible ways to present the data, history shows that the data is not always used in meaningful ways. The aim with the EOC dashboard was to enable decision makers to quickly analyse relevant IDSR data and make decision based on it. This is what led to the identification of a need for creating dashboard design guidelines for public health dashboards.

The project was initiated with a Skype meeting with HISP Uganda. This established an initial understanding of what they were doing and how far they had come in their work. We decided to have a field trip to Uganda to work closer with HISP Uganda as they acquired the initial requirements for the system. The meetings that I attended in Uganda were used to collect requirements from the users of the system. For this thesis, that meant understanding what data would be useful for the EOC to have in a dashboard. Traveling to Uganda and seeing how things worked instead of just being told about it was a very useful experience. During the stay, I made mock-ups of the dashboard. Unfortunately, I was not able to present these to the EOC, but they were discussed with HISP Uganda and we agreed it was a good start to prototype from. The plan was to remotely work on a prototype EOC dashboard that would use data from the same DHIS2 test server that HISP Uganda would develop the IDSR system on. The prototype was to be based on the requirements of the EOC in Uganda and would be tested remotely by a person working there.

Learning DHIS2, Prototyping the EOC Dashboard and Analysing DHIS2 Dashboards.

Coming back to Oslo from Uganda, time was spent on learning the technical details of DHIS2 to decide how to build the prototype EOC dashboard; in the core or as an external web application.

Time was also spent on researching how to best create dashboards by looking at dashboard design guidelines. A meeting with a student with expertise in user interface design was held to present the initial guidelines gathered from research. As this thesis is from a developer's point of view, it was useful to get input from a designer.

In March 2017, a DHIS2 expert meeting was held. The participants of this meeting include a lot of different organizations that use DHIS2 and it provided insight on what the users want. This was very useful when relating it to the guidelines, as it showed that requests from user sometimes contradict what the guidelines suggests. For example, some users did not like responsive design because this means the graphs changes place and it becomes confusing for them. This shows that the target audience guideline is very important and that using responsive design for keeping within the screen boundaries might not be the best thing to do. It gave me a lot to think about when evaluating the dashboard design guidelines for DHIS2. Further, I learned that DHIS2 is missing features that could increase data usage for some users. An example is the bullet graph which is not implemented in DHIS2, this graph can give better context to the data. The attendants at the expert

meeting sometimes use external applications (e.g. Power Bi[14] or Tableau[15]) for analysing data, as some graphs or features are missing from DHIS2. These external applications are usually not free and that means that the average user doesn't have access to them. Having to rely on external applications for some features that should be basic is not good when we have a system that targets developing countries. In the meeting the organizations also presented what they had been working on as external applications for DHIS2, which inspired improvements that can potentially be added to the core of DHIS2, as well as be used for an EOC dashboard. Based on these inputs, a prototype was developed to test the guidelines in practice. The prototype was sent to a person working at the EOC in Uganda to get feedback.

DHIS2 dashboards were also analysed to see if the guidelines could apply here as well. The reason for doing this is that dashboards in DHIS2 is created by users. A DHIS2 developer does not tailor a dashboard for a user, they create the tools that DHIS2 implementers or users can use to create dashboards. When researching dashboard design guidelines there were little mention of user created dashboards.

Prototype Feedback and Evaluating Guidelines

The prototype dashboard was sent to a user at the EOC in Uganda for remote testing and feedback. Some questions were provided for the user to answer. These questions were not directly about the guidelines, as they are guidelines for the developer and not for the user. Instead, the questions were about seeing if the prototype were heading in the right direction by following the guidelines. The limitation with this is that it is hard to say if the guidelines will contribute to increasing evidence based decision making based on the feedback from one person.

The feedback was positive, but the prototype was very limited and the user brought up many feature requests, most of which were already planned. For example, the user would like better drill down options in the dashboard for more detailed information. He also brought up a bigger feature request that had not been communicated during the field trip: a dashboard for tracking lab specimen. This will require more specifications, but that is not in the scope of this thesis.

After creating the prototype and analysing DHIS2 dashboards it was clear that the guidelines for dashboard design needs to be looked at in two different contexts. If a developer creates a tailored dashboard for a user, it is the developer that needs to follow the guidelines. If the users

[14] https://powerbi.microsoft.com

[15] https://www.tableau.com/

themselves creates the dashboard, the users will have to follow some of the guidelines, while the developers who creates the tools for the user created dashboards will also have to follow them, but in their own way. How the guidelines apply to user created dashboards is discussed in section 6.2.

4. DEVELOPING A DASHBOARD PROTOTYPE

This chapter will present the process of developing an alert dashboard that uses data from DHIS2. This includes how requirements were gathered, the planning of the prototype and developing it. The test server that was set up by HISP Uganda will also be described to get a sense of how data is stored and used.

4.1 Defining Requirements

The requirements of the EOC dashboard came from meetings with users and the requirement to focus on the minimum dataset needed for decision making, the EOC in Uganda also provided some PowerPoint slides that they create daily for disease monitoring (appendix B).

Though this thesis focuses on one example dashboard, I would like to present how I see it fit into the analytical part of the IDSR system:

1. At the landing page, the user is met with lists of active outbreaks and alerts. This overview dashboard should also include reporting rates and a map showing all active alerts and outbreaks. An additional feature that could be useful is a news feed that updates every time a new case is registered and indicates when a threshold is breached.

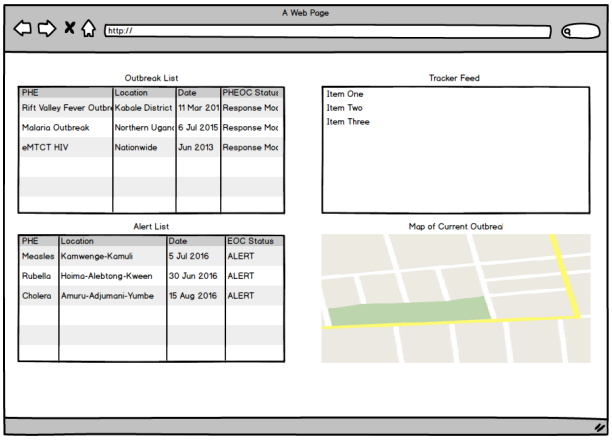


Figure 4-1: Mock-up of the overview landing page

2. When a user clicks on one of the alerts or outbreaks in the list, a new dashboard will be shown. This is where the event can be analysed by looking at daily received cases and weekly report compared to thresholds, historic data, locations of the individual registered and compare the data to possibly relevant factors like temperature and humidity. This is the focus of the EOC dashboard prototype.

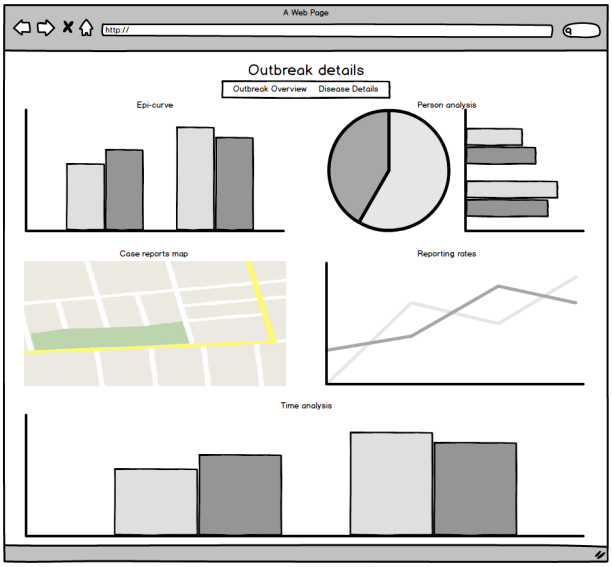


Figure 4-2: Early mock-up of the outbreak/alert dashboard

3. Additionally, a dashboard where the user can choose one of the IDSR listed diseases and look at routine and historic data about the specific disease without having triggered an alert.

Figure 4-3: Mock-up of disease routine surveillance dashboard

4.2 Planning

When planning the EOC dashboard, the objective was to create both the overview and the alert details dashboard. This was later scaled down to only include the alert details dashboard due to several reasons that will be explained through this chapter, but one of the reasons was to focus on the main point of the thesis; the dashboard design.

It was decided early to create the dashboard as a web application separate from the core of DHIS2 due to DHIS2 providing a web API that is easy to interact with, both for getting and saving data. This means that the developer can focus on creating the application in the web stack instead of learning how the core of DHIS2 is built. This will make it easier for developers who are not familiar with the frameworks that DHIS2 is built upon. Both raw data and the analytics data can be queried from the web API, but it was decided to use analytics data as this is faster to query. The application was developed using React[16] and a graph library called Highcharts[17], which is also used by DHIS2.

As IDSR required new features to be developed in the DHIS2 core, a test server was setup and it would update daily to get the latest features in DHIS2.

[16] https://facebook.github.io/react/

[17] http://www.highcharts.com/

4.3 Setting Up the Development Server

A development server was setup so that HISP Uganda could implement their proposed system, which I would also be using. The server was updated daily to the latest version of the DHIS2.

HISP Uganda implemented the following on the test server:

Generic Outbreak Event Program – This program use event capture. It will be used to manually registering an outbreak by the MoH. The details that is stored for an outbreak is: disease type, id, location, start and end date, status and an investigation file.

Generic Case Registration Notification Program – This program use tracker capture. It is used to register and track individual cases. Information about the patient is stored, including age, suspected disease, immediate outcome and location. There are then three stages for the tracking: Lab Request, Case Monitoring and Lab Results. Primarily, the Lab Results will be used for the dashboard, as this where the test result and the confirmed disease is stored.

Aggregated Reporting – This is used to register disease thresholds and aggregate cases. The weekly aggregate IDSR report must still be supported here, as not every organisational unit has enough resources to do case based reporting. Aggregated cases can be registered for the current week and backwards, these are tied to a ISO week and an organisational unit. The user reports total cases for each IDSR disease for the last week. Thresholds can be registered for a year at a time, and these are tied to an organisational unit, a ISO week and a specific disease.

Validation Rule – The alerts were generated by setting up validation rules for checking if the number of cases exceeds the thresholds. Currently, this will only generate an email that is sent out to relevant users, it does not persist the alert in the system.


Dysentery Possible Outbreak
HIGH: IDSR Possible Dysentery Outbreak :- Please review data from Cardinal Hospital Gateway PHC, for the period 2017W10 the reported values are 2.0 if greater than the threshold 1.0

Possible Measles Outbreak
HIGH: IDSR Possible Measles Outbreak :- Please review data from Cardinal Hospital Gateway PHC, for the period 2017W10 the reported value 6.0 is greater than the threshold 2.0

Possible Outbreak
MEDIUM: IDSR Possible Malaria Outbreak :- Please review data from Cardinal Hospital Gateway PHC, for the period 2017W10 the reported values are 11.0 if greater than the threshold 10.0

Possible Measles Outbreak
HIGH: IDSR Possible Measles Outbreak :- Please review data from Cardinal Hospital Gateway PHC, for the period 2017W11 the reported value 7.0 is greater than the threshold 2.0

Possible Outbreak
MEDIUM: IDSR Possible Malaria Outbreak :- Please review data from Cardinal Hospital Gateway PHC, for the period 2017W11 the reported values are 12.0 if greater than the threshold 10.0

Figure 4-4: An auto generated alert email sent from DHIS2

Additionally, I implemented a third program to handle alerts. This was to persist the generated alerts, which is not currently supported in the DHIS2 core. More details on this will be presented later.

IDSR Alert Program – This program use event capture. It will store the automatically generated alerts. These are generated when the number of cases exceeds the weekly threshold for a disease. It stores information about the registered alert, including disease type, location of alert, the week and date the alert triggered, the number of cases and the threshold, the validation rule that was broken and if the alert has been investigated.

4.4 Initial Scope

With the limitations in DHIS2 for persisting alerts, the external application had to generate the alerts. This was very cumbersome, as the tracker, aggregate and threshold data was not bound to each other. This meant comparing the names of the disease, adding up the tracker and aggregate data, comparing it to the threshold and then saving the alert in to DHIS2 to persist it. This was separate from what was already going on with the validation rules. Testing this meant cluttering the database with a lot of auto generated data, so a local instance of DHIS2 with a copy of the database was set up to work on instead.

An additional challenge when creating external web applications for DHIS2 is keeping it generic so that it can be used with any DHIS2 instance. Since DHIS2 is very flexible, users can create their own programs and data elements, these get a unique identifier (UID) which is not the same between the instances. These UIDs are used when querying the web API, which means that the external application needs to be mapped to the correct UIDs or the metadata can be imported to DHIS2 instances, but there are no guarantees that the UIDs are not taken in existing databases.

As persisting alerts is an upcoming feature in the DHIS2 core the focus shifted fully towards the alert dashboard. Manual entered test data was used instead so the focus could be on the design of the dashboard.

4.5 Creating the Dashboard

The development of the dashboard was done in iterations with few changes in each iteration. At first, a few components were added, then it was checked against the guidelines to see what could be improved and then a new iteration and so on. The iterations will be presented as what was done and what were the mistakes that needed to be fixed in the next iteration.

4.5.1 First Iteration

The first iteration included setting up the communication with the web API to get the data. The following components were added:

Bullet chart – This would show the total confirmed cases (tracker and weekly report) compared to the threshold.

Alert summary – Included general information about the alert. This is information that will be listed as the user clicks the alert they want to watch, but it should also be included in the dashboard as well so the user can see where and when the alert was triggered and for which disease.

Bar chart – Shows number of confirmed cases registered daily with tracker and the cases registered with the weekly report. It also included a visual line that shows the threshold.

Map – This will show the location of the registered tracker cases. It uses clustering so a user can see if a lot of cases are located close to each other. It will not show the cases from the weekly report as these do not register locations, but an alternative could be to put these in the position of the organisational unit that registered the cases.

Evaluating this with the guidelines in mind, the following needed to be addressed:

- The bullet chart was unnecessary as it would only show the total number of cases compared to the threshold. There was no more context to show, either the cases are under the threshold or have reached it. This was a case of choosing the right display media.
- The screen boundaries had not been addressed yet so the dashboard wouldn't stay within the boundaries on smaller screens.

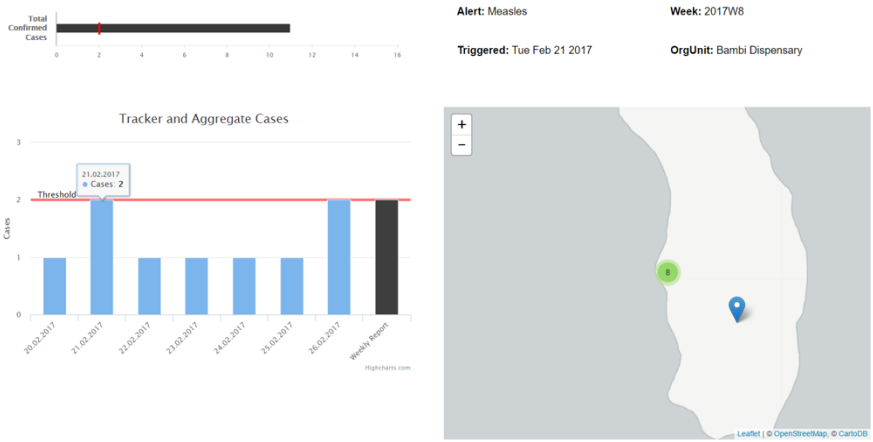


Figure 4-5: First iteration of the alert dashboard

4.5.2 Second Iteration

In the second iteration, the bullet chart was removed and replaced with the raw numbers in the “alert summary” component. The dashboard layout was set up as the inverted pyramid, where the most important information is at the top and then more detailed information is shown afterwards. A new colour theme was tested and the components were separated by using cards[18].

Evaluating this with the guidelines in mind, the following needed to be addressed:

- The new colour choices were based on having a dark theme. It might look nice, but it requires brighter colours for the displayed media which contradicts the guidelines. It is not consistent with the theme of colours that is used in DHIS2, and consistency is important.
- Separating the components in individual cards instead of putting them flat on the background was a choice of aesthetics. Even though the human perception will know each component from each other without the card layout, it will still be more pleasing to look at when encapsulating each component.
- The “alert summary” component contains information that is might not be a top priority and should therefore not be at the top of the screen, but this is a choice of grouping the text together in the dashboard. This makes the dashboard look less cluttered.

Figure 4-6: Alert dashboard after the second iteration

[18] https://material.io/guidelines/components/cards.html

4.5.3 Third Iteration

In the third iteration, the colours were changed back to be more consistent with the DHIS2 design and align better with the guidelines. Another component was added, that would show historic data for the last four weeks compared to the threshold. Screen boundaries were addressed, and the dashboard is responsive.

Evaluating this with the guidelines in mind, the following should be addressed:

- More work is still needed for keeping within the screen boundaries. The components scale, but on smaller screens the components will exceed the boundaries.
- The “alert summary” component scales well on smaller screens, but the information needs to be closer together on larger screen so it required less visual travel time for the users to look at.

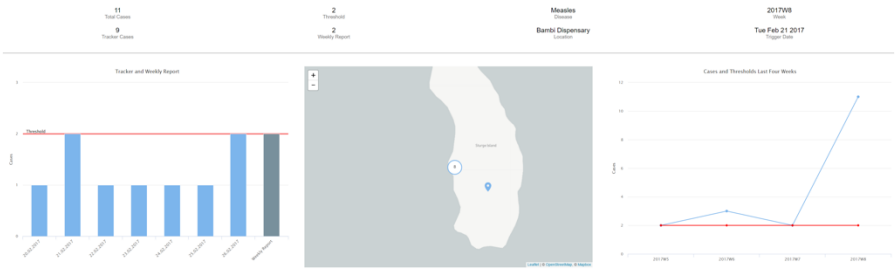


Figure 4-7: The dashboard without the card layout. The image is from a very large screen and it shows that the "alert summary" information is very far away from each other

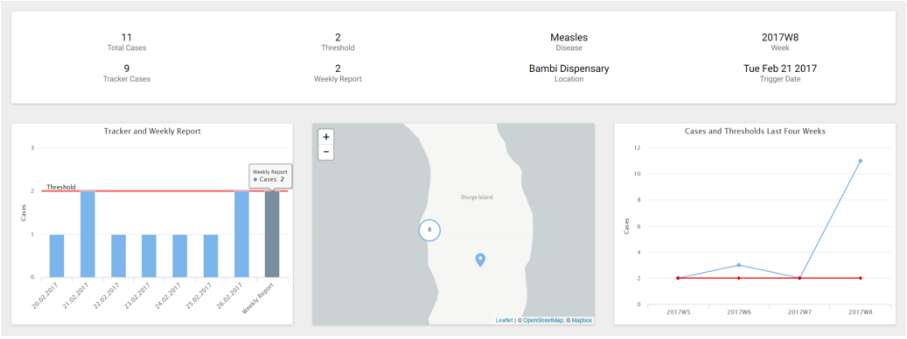


Figure 4-8: The dashboard using card layout is more visually pleasing to look at. This image is from a normal sized desktop screen.

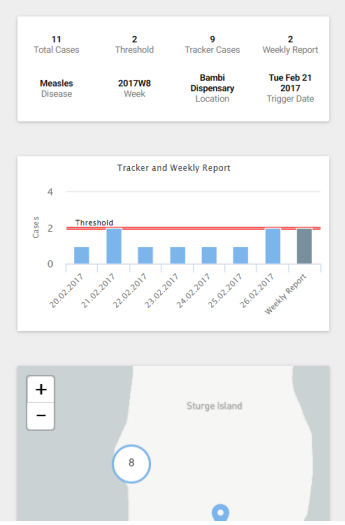


Figure 4-9: The dashboard exceeds the screen boundaries on smaller screens. The data in the "alert summary" component is closer to each other

4.5.4 Further Development

Further development is needed for multiple reasons. There are still components missing which will be useful for the EOC in Uganda to have, some of which will require more test data. The issue of screen boundaries and data layout needs to be addressed more based on user feedback, especially since the dashboard will have more components. What is aesthetically pleasing can vary based on culture, but I think the main priority here is to keep it consistent with the DHIS2 looks.

Missing Components

The following is a shot list of features has been compiled from looking at the EOC daily slides and the IDSR technical guidelines, these requires feedback from the EOC.

- Showing historic data for the same week for the last 5 years. This can help for detecting trends.
- Having multiple layers on the map that can show population, temperature and humidity data.
- Person analysis, for example age and gender, but this depends on the data collection.
- Showing not only confirmed disease cases, but also suspected cases and confirmed deaths.

4.6 Feedback

The EOC worker indicated that the data in the dashboard were good, it is based on the minimum dataset needed for them to make evidence based decisions. Additionally, he requested more historic based data for the same period for the last three years instead of five, as he was worried that five years would make the graph harder to analyse. Person analysis (age and gender) seems to not be needed, as there was no request for this and the newer EOC daily slides did not include this. I had also suggested having multiple map layers[19] so the user can choose to look at population, temperatures and humidity, but the health worker mentioned that this would be a "nice-to-have" feature, but not something that would contribute to the decision making for them. The last thing he mentioned that would be very useful is drill down functions for periods and locations. For example, if there was an alert triggered for a district, he can drill down and see where these were reported at the facilities Additionally, he requested a dashboard for specimen tracking. This had not been discussed during the field trip and it is out of the scope of this thesis, but this could for example be part of the overview page as seen in Figure 4-1. The specification of a specimen tracking dashboard will need to be discussed in detail with the EOC.

[19] http://www.caliper.com/glossary/what-is-a-map-layer.htm

5. DASHBOARD DESIGN GUIDELINES IN DHIS2

In this chapter, two DHIS2 dashboards will be analysed using the dashboard design guidelines from section 2.2.2. First, a standard DHIS2 dashboard, and second a more interactive dashboard is analysed. The interactive dashboard is currently in development by HISP Tanzania and is not yet finished, but it will be analysed in its current state. To clarify, it is not a specific user created dashboard in DHIS2 that is the focus of the analysis, rather the focus is on DHIS2 dashboards in general.

The reason for testing the dashboard design guidelines for DHIS2 is that dashboards are user created and not tailored by a developer for a specific purpose. To clarify, there are two roles that are involved in the creation of DHIS2 dashboards. Developers creates the DHIS2 platform which contains the tools to create a dashboard. Dashboard creators are users or DHIS2 implementers that use the given tools to create dashboards for themselves or for other users.

5.1 Analysing a Current Dashboard in DHIS2

A strength and at the same time a weakness in DHIS2 is its flexibility and the opportunity for users to create their own dashboards. The developers give options for displaying the data, but it is the users that choose which display media they want to use and how to organise them in the dashboard. A dashboard is created by the user and the components the user want to show is chosen from the user created favourites. When a user creates a favourite, he chooses the information he wants to show and the display media to use, and then saves the

favourite with a name. This favourite will only show the data that the user has chosen and if the user wants to have an identical graph with different data he needs to create a new favourite with other variables and then save that as well with a new name. To explain this better, here is an example for disease surveillance: A user wants to view total confirmed cases of five different diseases for ten locations for the last seven days in a graph. The user can make one graph that displays all this information, but the point here is to have these in separate graphs so they can be used in a dashboard that shows data for a specific disease as the Figure 4-3 demonstrates. This means if a user wants to create five dashboards, one for each disease, he needs to manually create the favourites to be displayed for each dashboard.

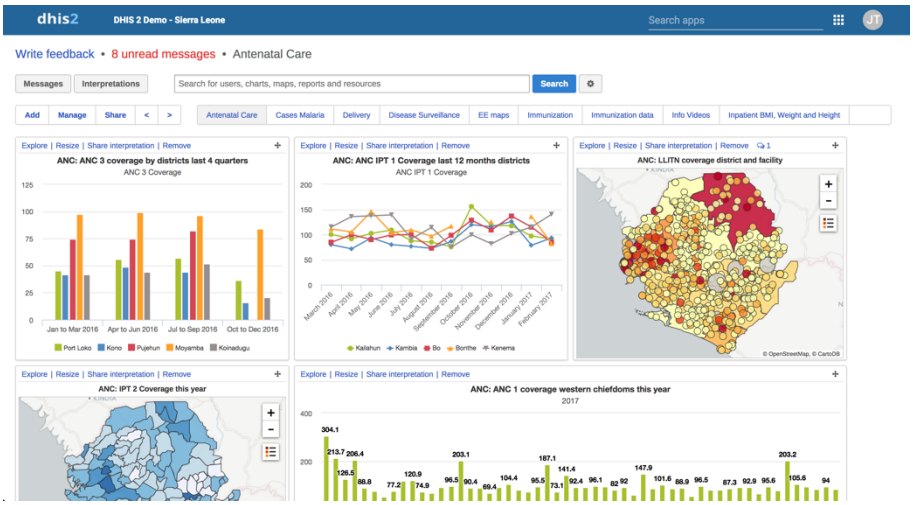


Figure 5-1: Example of a dashboard in DHIS2 created by a user

Target Audience

DHIS2 can have many thousands of users spread around the world working with different instances of the software. The gap between user's knowledge and experience can be huge and therefor it is hard to know what the user needs and even harder to get feedback from certain users. Another challenge is that there are so much different data in public health that it would probably be impossible to create tailored dashboards to cover everything that is why in this case it is better for the users to create the dashboards themselves. This means it is up to the developers to give the users the best tools possible to create these dashboards.

Screen Boundaries

It is up to the user what they want on the dashboard and there is no limit to how many items they can add, therefor the screen boundaries will

eventually be exceeded. The display media can be resized in three different settings for the width, but they lack height scaling.

Display Essential Data

Again, since the dashboards are user created it is up to the user which data to show.

Data Needs Context

This is something that is still lacking in DHIS2. There are some possibilities of setting plotlines as targets in the graphs, but some users want to add more context. An example from the DHIS2 expert meeting was that the user would like to set multiple targets showing bad, medium and good, like as shown in the bullet chart in Figure 2-7.

Data Layout

This is up to the user creating the dashboard, the items can be rearranged by drag and drop.

Choose the Right Display Media

How the data is shown is up to the users, but there is a limited set of graphs to use and more should be implemented. A challenge here is that the user themselves does not know which is the best way to display the data they want to have in the dashboard. Another challenge that was presented at the DHIS2 expert meeting is that some users are stubborn and don't want to change the display media, because they have used another type for many years.

Display Media Design

The graphs themselves use Highcharts for displaying the data which looks good. The dashboard will still have a lot of clutter, due to the settings that can be done for each component. As the following figure shows, at the top of each display media there are four things the user can do. It could be solved more elegantly by for example using icons, this would bring less clutter to the dashboard.

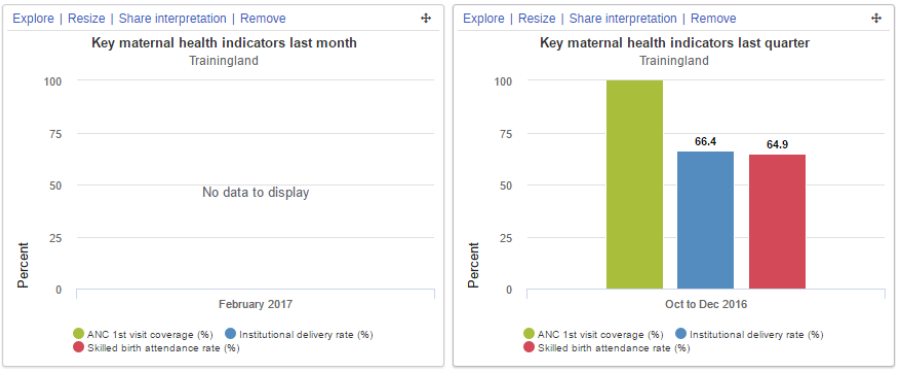


Figure 5-2: Two components from a DHIS2 dashboard

Highlight Important Data

This is currently not possible.

Colour Palette

Follows the standard pre-set in Highcharts for the graphs, but in the maps, it is possible for the user to choose from pre-set colour scales. At the DHIS2 expert meeting, many of the attendees indicated that they would like to be able to freely choose colours.

Make the Dashboard Attractive

Making a dashboard attractive can be very subjective, but keeping a simple and clean look that does not take away focus from the displayed data is what is most important. There are certainly some improvements that can be made as mentioned earlier in the display media design.

Time and Update

Showing the time that the data is from will be up to the user and how they customize the items that they use to display the data. For the updates, it really depends on how the items are configured by the user, often these are relative times. For example, a graph can show data for the last seven days and then it would update each day.

Additional Findings

A feature that would be very useful from an IDSR perspective is to have template dashboards. A user could create a dashboard and put in the items that he wants to display and there would be a global filter to choose time and location to be displayed in the graphs. This would be especially useful for an IDSR routine dashboard if one of the filters was to choose a disease. This would not only be great for IDSR, at the DHIS2 expert meeting other attendees also expressed the need for this.

The dashboard does not provide good enough tools for drilling down into the information. It requires the user to navigate away from the dashboard into another application. As most of the displayed media shows data over time it should be easier to drill down into different periods. An example is if a user is looking at yearly data, he should be able to click on a year and then get the monthly data for that year, currently the user needs to go into another application and manually change the period to display.

Summary

Though DHIS2 dashboards are user created, the guidelines should still apply. The important thing here is that both developers and users need to be aware of the guidelines. For the developers, the guideline should be focused on helping the developers to create the best possible dashboard creation tools for the users. For the dashboard creators, the guidelines must focus on teaching them how to best create dashboards for the target audience so that it can and will be used for evidence based decision making. There are missing features in DHIS2 that can potentially improve evidence based decision making, but even if they are implemented dashboard creators need to be educated in how they should be used. With the global user base that DHIS2 has it can be hard to effectively communicate this to all the users, especially when the user expertise is varying. A suggestion is to create interactive tutorials within DHIS2 for creating good dashboards. This can help the dashboard creators to create better dashboards for many users and is an effective way to reach out to the large and varied user base. The dashboards in DHIS2 should still follow the guidelines from Table 2-3, but set in different context if you are a developer or if you are a user that will create the dashboard. This will be discussed in section 6.2.

5.2 Interactive Dashboard

The interactive dashboard brings some new useful features as well as giving the dashboard a cleaner look. Only things that have been changed from the current dashboard system in DHIS2 will be presented. If a guideline is missing it means that it has not changed from the current dashboards in DHIS2. Again, keep in mind that this dashboard is still in development and this analysis is based on the current version as of 19.03.17.

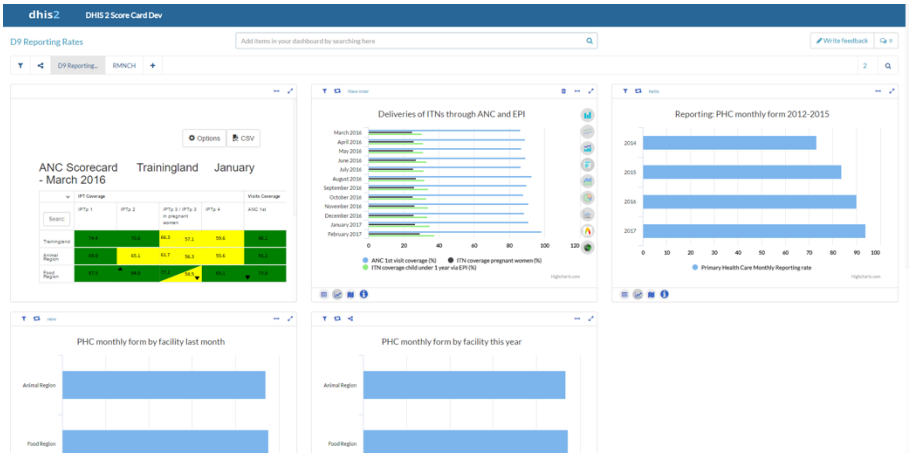


Figure 5-3: An interactive dashboard is in development for DHIS2

Target Audience

The interactive dashboard brings some new features that can make it better for the users. It will let users choose the location and period that the dashboard will display, meaning that it works a little more like a template dashboard where some variables can be changed. This can be done on a per item basis or for the whole dashboard. It also addresses a problem that was discussed at the DHIS2 expert meeting: users can be confused at what they are looking at because definitions can be unclear. Users can now get the definitions of the data without leaving the dashboard.

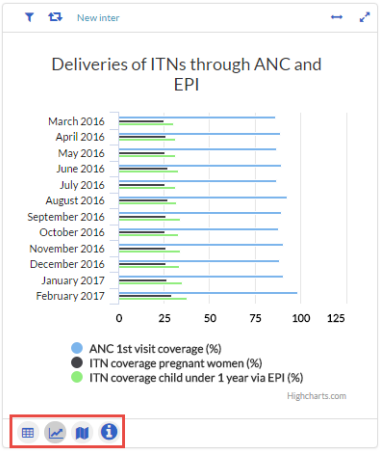


Figure 5-4: Users can view the data in a table, graph or a map, as well as checking the definitions of the data without leaving the dashboard

Choose the Right Display Media

The interactive dashboards solution to this is to let the user change the display media in the dashboard. The option to change graph type will only show up when the user mouse over the item they want to change. Currently, a problem with this is that each graph will start out as a horizontal bar graph and if the user changes this it will not persist. There are also many of the options that will probably not be useful and therefor shouldn't be on the list. Though it is a nice feature, we must remember that extra features like these can confuse the user and might not benefit with the data usage, this can go both ways.

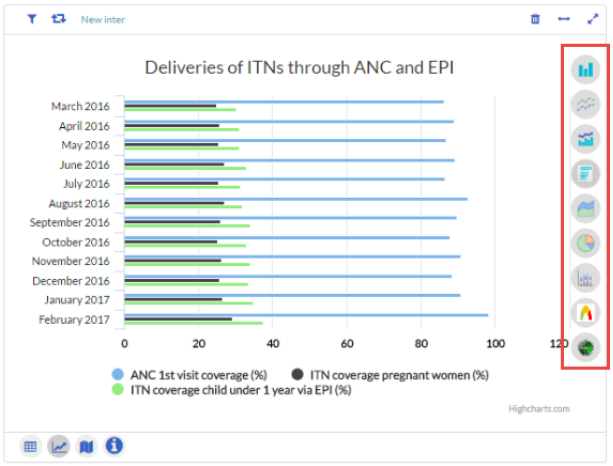


Figure 5-5: The user can change the graph type without leaving the dashboard

Display Media Design

Most of the clutter has been improved by adding icons instead. When the user mouse over the icons, a label is shown that describes what the button does.

Make the Dashboard Attractive

It keeps the simple and clean look, but some of the clutter has been improved by adding icons instead of labels.

Additional Improvements

The drilldown feature of details about periods is still not implemented, but users can expand one of the graphs to fill the screen as a popup instead of being redirected to another application.

Summary

The interactive dashboard improves a lot of things from the standard DHIS2 dashboards, but there is still a lot that can be improved further.

Only things that has changed was mentioned in this section, which means there are still things in the guidelines that DHIS2 does not have. This dashboard provides more help to less experienced user in that they can view information about what the data in the graph means, it also allows the user to change the display media, but as mentioned that can be both positive and negative. Some of the clutter has been addressed by using icons instead of text where this is appropriate. Drilldown functionality has been improved, but there are still things to improve here as well.

5.3 Lessons Learned

Both from analysing DHIS2 dashboards and attending the DHIS2 expert meeting it is clear that there are still are improvements to be made both in terms of design and features for DHIS2. What makes it hard to just follow the mentioned dashboard design guidelines is that the dashboards in DHIS2 are not tailored by developers for a specific analytical task for some specific users. DHIS2 is flexible and lets users create their own dashboard, while developers give them the tools to do so. In my opinion the guidelines still apply, but with small differences for the context of being a developer or a dashboard creator, which will be discussed in section 6.2. There is also a very big span in the user knowledge and technical skills, which was also a discussion at the DHIS2 expert meeting. If a user with little knowledge in computers and analytics is presented with an overwhelming number of options to create a dashboard it might not be in the users best interest. While on the other hand, expert users might want more options so they can utilize DHIS2 for all their analytical needs. At the DHIS2 expert academy someone suggested to have separate modes depending on the knowledge level of the users, for example an expert mode which gives more options and a beginner mode with less options. I think educating users through interactive tutorials that shows them the dashboard design guidelines could also help them understand how to create better dashboards.

6. DISCUSSION

In the following chapter I will discuss my findings from the two earlier chapters. First, findings from chapter 4 will be discussed, then from chapter 5, followed by a general discussion of the observations from the two chapters.

6.1 EOC Dashboard

There is a lot of functionality in a dashboard that the EOC in Uganda would find useful for evidence based decision making. This would require multiple dashboards serving different functions (IDSR routine, alerts and outbreaks, specimen tracking). The prototype that was created was very limited and cannot be used for anything in the current state. The goal of this prototype was to get feedback from the EOC in Uganda, to see if by following the dashboard design guidelines the created dashboard was heading in the direction that would be useful for evidence based decision making.

6.1.1 Observations

When prototyping the alert dashboard there were some guidelines that were easier to follow than others. The following is my thoughts after using the guidelines:

Target Audience – The dashboard that is built is software. In software development, it is often not good enough to think about the target audience, but the developers also need to interact with them. The development of the dashboard should be an iterative process where the user is involved.

Screen Boundaries – This is a simple guideline, but how hard it is to follow depends on how much information is in the dashboard and which screen sizes will be used to view it. The guideline ties into other guidelines: display essential data and display media design. If there isn't too much data and the various display media scales well without making the data hard to read, keeping within the screen boundaries should be doable, even on smaller screens.

Display Essential Data – As this prototype was based on IDSR minimum data required for evidence based decision making, there were not a lot of data left that could be used to clutter the dashboard. This will usually not be the case, so it is important to work together with the users to find what is the essential data.

Data Needs Context – There is not much to say about this: If there is extra information that will give context to the data then use it.

Data Layout – This tie back to interacting with the users, as a developer it can be hard to know which data is most important and should be put first or grouped together.

Choosing the Display Media – This will depend on the data that will be shown. There are great resources for helping with the choice of display media: (Abela, 2009; Few, 2016).

Display Media Design – There are many good resources for good display media on the internet and there is no need to reinvent the wheel. How they are configured is up to the developer, but keep the data-ink ratio in mind.

Highlight the Important Data – There is not much to say about this for the prototype dashboard. The dashboard will help in analysing an alert and there isn't much to highlight, other than which days the thresholds were breached. This does not mean that it is a bad guideline, it means that there might be dashboards where it does not make sense to highlight things.

Colour Palette – This ties in with highlighting important data and display media design. Use bright and hot colours to highlight, other than that use more neutral colours that does not fight for the attention of the user. During the DHIS2 expert meeting some attendees indicated that they would like to use the colours of their company logos.

Make the Dashboard Attractive – This can be very subjective and cultural based, but even though this prototype is an external application it should be consistent with the DHIS2 design so it is familiar to the user. If the dashboard does not look good that in itself can be a reason users don't want to use it.

Time and Updates – It is important that the user knows when the data is from. In the prototype, the dashboard was meant to be navigated to

from a list as shown in Figure 4-1, but even though the time and location were shown in the list it is still important to display these in the dashboard as well so the user always knows what they are viewing. Letting the user halt updates will really depend on what kind of dashboard it is, for example if the dashboard is updated in real time the user might want to freeze it to study the information more.

As this kind of dashboard is tailored by a developer for a specific use case and for specific users the guidelines should apply just as much here as to other domains. Creating the dashboard should be an iterative process and I failed to follow the guidelines myself when designing the dashboard, but faults were addressed in the next iteration. Designing a dashboard is the same as developing software, you can create a viable product by using the waterfall model[20] for developing, but using an agile approach where you interact with the user and get feedback that you can adapt to under the development will usually end with a better product that is in line with what the user want.

6.1.2 Dashboard as an External Application

When you log into DHIS2, the first thing a user see is a dashboard. Dashboards are a large part of DHIS2, but it still doesn't have all the required features that would be needed for the EOC dashboards. At the DHIS2 expert meeting there was a request for what was called "global filters". What this means is that a user could create a dashboard as a template and then choose data to be shown by global filters. For example, this could be used for setting up a dashboard for IDSR routine data, where the user could then choose a disease from the global filters and then the dashboard would be filled with the data for that specific disease. If the validation rules could generate persisted alerts when a disease threshold was breached, this could be used to generate alert dashboards as well. These are features that is not currently implemented in DHIS2, but it could be a way to have the EOC dashboard as a part of the DHIS2 core, instead of creating an external application. DHIS2 does encourage developers to create external web application, but due to the way DHIS2 is built this will often require the developers to write a lot of code for checking meta data if the application is to be generic and usable by all DHIS2 instances. If these features were to be developed into the core of DHIS2, then both the IDSR routine dashboard (Figure 4-3) and the alert analytics dashboard (Figure 4-2) could be part of the core, but the overview dashboard (Figure 4-1) and specimen dashboard would still require more specific tailored applications. Another reason to develop dashboards as external application is to be able to have multiple data

[20] https://en.wikipedia.org/wiki/Waterfall_model

streams. The EOC in Uganda has some things in their EOC daily slide (appendix B) that is not available in DHIS2. For example, they have refugee data as the thresholds for alerts are lower than normal in refugee camps due to how fast a disease can spread.

6.1.3 Reflection

For the EOC dashboard(s), there is a lot of work to be done before it can be used by the EOC in Uganda. The project will be continued by HISP UiO, because there is a need for this system as evident by the situation in Uganda. Going forward, the developers at HISP UiO must think about this as a global project, other countries will also benefit from an IDSR system in DHIS2.

Programming

As mentioned in section 4.4, a lot of time in the start was spent on generating alerts and persisting them, while also trying to keep the program generic. This was a lot of work to do when the focus should be on having a good dashboard that can facilitate improved evidence based decision making. As the IDSR system were in such an early development there were much work to be done before starting to develop the EOC dashboard. There are still upcoming features in DHIS2 that will make it easier to create EOC dashboards. For example, persisting generated alerts. To avoid a lot of double work it would be better to see what the DHIS2 developers will implement to support this and then from there see what is missing for creating EOC dashboards.

Working with the EOC in Uganda

As mentioned, working with the users while developing is important. The project could have benefited from having more mock-ups to share and discuss with the EOC before starting the development. Continuing this project, it could be beneficial to have more discussions with users in the EOC. Not only through emails, but also live conversations, be it either remote or on location. It is easier to get valuable feedback from the users through live interaction where you discuss the prototype together.

The Prototype Design

There are still improvements to be made for the design of the prototype dashboard, which as suggested can be done in iterations. The dashboard design guidelines are meant for developers to follow to create good dashboards for users, but a user experience (UX) designer could also be involved when designing the dashboard.

6.2 DHIS2 Dashboard

Analysing DHIS2 dashboards and attending the DHIS2 expert meeting provided information about how the dashboards are currently used, which features that are available and which are missing. The users at the DHIS2 expert meeting were, as the name suggests, experts. They work with all kinds of users so they did not only provide feedback on what features they would want, but also for other less experienced users. A discussion that came up was that DHIS2 is flexible and simple and some features might not be in DHIS2 because it can overwhelm users with options. It was clear that there were some things that needs to be implemented in DHIS2 for it to be a better tool for data usage. For example, allowing graphs to show more context for the data. One of the points of the discussion was to separate what was shown to expert users compared to less advanced users. That discussion is out of the scope of this thesis, but it is a great point. The average user might be overwhelmed if they have the same options as experts and that can lead to the user not wanting to use the tools. Research has been done on this before and they bring up a lot of the same challenges that the DHIS2 dashboards has when creating tools for user customisable visualisation: (Elias & Bezerianos, 2011; Grammel, Tory, & Storey, 2010; Heer, van Ham, Carpendale, Weaver, & Isenberg, 2008; Viegas, Wattenberg, Ham, Kriss, & McKeon, 2007). Analysing DHIS2 dashboards in accordance with the guidelines was to see if the dashboards are already following the guidelines and if not could they benefit from it.

6.2.1 Observations

As has been mentioned several times, the dashboards in DHIS2 are user created. When researching dashboard design guidelines there was little mention of dashboards that are created by the user and how they differ from dashboards that are tailored by developers to a user. Analysing the dashboards in DHIS2 was done based on the researched guidelines, but to apply them in DHIS2 they need to be viewed in two different contexts: guidelines for the user that creates the dashboard and guidelines for the developers who creates the tools used by the dashboard creators. The dashboard design guidelines will therefore be discussed in two parts: guidelines for developers and for dashboard creators.

Guidelines for Developers

Target Audience – Developers are creating tools for the users to create their own dashboard. This means that they need to think about what tools are useful and how will they be used. Developers should communicate with dashboard creators to they can provide exactly what is needed. As mentioned, at the DHIS2 expert meeting there was a discussion on differentiating between experts and less experienced

users. If this is the way to go then the developers need to communicate with both user groups to create the tools that suits each purpose.

Screen boundaries – As the dashboards are not limited in how many items can be displayed on a dashboard, it is up to the developers to at least create display media that scale well for all screen sizes. This means making the items responsive as well as the dashboard itself. It ties in to the display media design guideline.

Display Essential Data – Again, this also ties into designing the display media design in that it should not display unnecessary precision in numbers and the displayed data should be directly analysable by the user instead of having the user process the data themselves.

Data Needs Context – Giving the users the tools to do so. This means providing graphs that allows for comparison between the displayed data.

Data Layout in a Dashboard – The placement of the data in the dashboard will be up to the users, but giving them flexibility to place the data as they want is up to the developers.

Choosing the Display Media – The choice of display media will be up to the user, while it is up to the developers to provide good options for users.

Display Media Design – This is the same as the guideline originally was: the display media must be designed well so it can most effectively convey the displayed data.

Highlight the Important Information – Again, give the users tools to be able to highlight the important data in their dashboards.

Colour Palette – Give the users tools that allows them to choose the colour they want to use.

Make the Dashboard Attractive – Choose a design that is attractive, both for the display media itself and the dashboard, and keep it consistent.

Time and Updates – Provide the tools needed by the users so they can customize their dashboards to show time for when the data is from and allow for halting updates.

The guidelines for the developers revolves around creating the best tools for the users. If the users have the tools for creating good dashboards in line with the guidelines, then that can help facilitate improved evidence based decision making. The next step is to educate dashboard creators on how to use the tools to create good dashboards.

Guidelines for Dashboard Creators

The dashboard design guidelines for dashboard creators will be mostly the same as stated in section 2.2.2.

Target Audience – The target audience for dashboard creators can be themselves and other end users. If the dashboard should be used by other people than the dashboard creator himself, then they need to think about the other users as well. At the DHIS2 expert meeting, one of the attendees demonstrated a dashboard where a user had over forty items on one dashboard. That dashboard is not very good if you want to share it with others, it will be overwhelming and cluttered.

Screen boundaries – There isn't a limit to how many items can be put on a dashboard, but the dashboard creators need to know that putting too much in a dashboard will do more harm than good. Better scaling support will lead to more useful data compressed into a smaller space, but dashboard creators can still put too much information in the dashboard.

Display Essential Data – This stands as the original guideline: only display data that is need for evidence based decision making.

Data Needs Context – If the dashboard creators have the tools available to do this in the graphs, the data will be more meaningful. Setting multiple targets to see if the measure is good, medium or bad and how far it is from each of the targets will provide better context than having one measure compared to a target.

Data Layout in a Dashboard – The most important information should be at the top as this is where the user usually starts to analyse the information on the dashboard and data that should be compared must be grouped together.

Choosing the Display Media – The dashboard creators need to learn what is the correct display media to choose for what kind of data.

Display Media Design – This does not apply to the dashboard creators, only for the developers.

Highlight the Important Information – Dashboard creators should be allowed to highlight important information, be it manually or by automatic functions, for example by validation rules. This will depend on how flexible the tools provided by the developers are.

Colour Palette – This stands as the original guideline: stick to a few colours and think about accessibility (e.g. colour blindness) when choosing.

Make the Dashboard Attractive – Dashboard creators can make the dashboard more attractive by choosing the correct display media, but the design is up to the developers.

Time and Updates – Display the time so the users know when the data is from. Halting updates should be allowed if it is needed in the dashboard, but this will depend on if the tools that the developers create allows it.

The dashboard design guidelines for dashboard creators revolves around correctly using the tools that are provided by the developers. Even if all the necessary tools are provided it does not guarantee that the dashboard will be good, the dashboard creators also need to know how they can best utilize the tools.

User Created Dashboard - Design Guidelines		
Guideline	**Developer Description**	**Dashboard Creator Description**
Target Audience	Think about the dashboard creators and end users when creating the dashboard creation tools. Communicate with users for feedback and suggestions.	Keep audience in mind. If other people than yourself will use it, think what is best for them. Communicate with users.
Screen Boundaries	Create display media that scales well and make the dashboard responsive.	Do not overwhelm or confuse the user by filling the dashboard with items outside of the screen boundaries.
Display Essential Data	Do not have unncessary precision in numbers. Create the display media so that the user can display data that is directly analysable without the user having to process the data.	Only display data that is essential for the evidence based decsision making.
Data Needs Context	Provide display media that allows for more data context.	Give context to the data by displaying multiple targets for the measure.
Data Layout	Give the users flexibility to order the items on the dashboard as they want.	Group data that will be compared and keep the most important information at the top.
Choosing the Display Media	Provide good options for the users. Do not include graphs that is not fit for dashboards.	Use the display media that most effectively communicates the data.
Display Media Design	Design the display media so it effectively communicates the data that is shown. Reduce non-data pixels.	Does not apply to dashboard creators.
Highlight the Important Information	Provide users tools to highlight information manually or automatically (e.g. by validation rules).	Highlight important information if you want to capture the users attention.
Colour Palette	Provide users tools to choose colour palette.	Stick to a few colours and think about accessibility.
Make the Dashboard Attractive	Choose a design that is attractive, both for the display media and the dashboard itself.	Does not apply to dashboard creators.
Time and Updates	Provide tools for displaying when the data is from and allow halting of updates.	Display time from when the data is from. Allow for halting updates if necessary.

Table 6-1: Suggestion for dashboard design guidelines for developers and creators of user created dashboards

6.3 Dashboard Design Guidelines in Public Health

The guidelines for user created dashboards builds upon the guidelines from section 2.2.2, which is for tailored dashboards. At first my thought was that maybe these guidelines needed to be altered to better fit with public health dashboards. Testing out the guidelines in practice, analysing DHIS2 dashboards and attending the DHIS2 expert meeting has made me believe that the guidelines can hold up just as well for public health dashboard as other types of dashboards. What makes the guidelines not directly applicable for DHIS2 dashboards is that these dashboards are user created, while the original guidelines fit better for developers. DHIS2 is a platform that targets many users of various expertise and knowledge and aims to be flexible and that comes with benefits as well as challenges.

The guidelines in Table 6-1 are just a suggestion and needs to be tested and refined. Still, there won't be improvements unless people are aware of the guidelines, and that means communicating them to developers and dashboard creators for DHIS2. This is a lot of people and one way to tackle it for dashboard creators could be have interactive tutorials inside the DHIS2 platform. The guidelines could also be researched and tested further, for example if the dashboard should have responsive design. This is something that some users find confusing as content changes place, but the extent of this problem is unknown. Responsive design is a common web design practice for targeting smaller screens, but as one of the guidelines says: think about the target audience. In addition to the guidelines, more features that better support user created dashboards should be implemented in DHIS2 in accordance with the guidelines, this includes better drill down functions for periods and organisational units, as well as graph options and filters for easily changing the displayed data without much customisation. If the correct tools are implemented and people learn to use them then this can facilitate improved evidence based decision making through dashboard usage.

Looking back at the goals of this thesis set in section 1.1 here is a few comments on each of the goals:

Identify general dashboard design guidelines – the goal was reached and guidelines were identified.

Provide an overview of a suggested EOC dashboard and a prototype – A prototype was developed, but it only covered a small portion of what an EOC dashboard should be able to do. Section 4.1 provides an overview of the suggested full system. I still see this goal as only partly reached, as the prototype was small and new requirements (specimen tracking dashboard) for the EOC dashboard came very late so the overview in section 4.1 will still need to be refined.

Provide dashboard design guidelines, based on the EOC dashboard and prototype, for public health data, more specifically in DHIS2 – I suggest the guidelines should not be public health data versus other data, but rather they should be for tailored dashboards versus user created dashboards. I will argue that this goal was reached as the goal was to identify guidelines that can facilitate improved evidence based decision making in DHIS2, which I believe can happen with the suggested dashboard design guidelines in Table 6-1. Though as mentioned, the guidelines themselves needs to be communicated and understood by the people that should use them before improvements can be seen.

The following are suggestions for what HISP UiO can do to potentially improve evidence based decision making by users of DHIS2:

- Test and refine the guidelines from Table 6-1. These needs to be communicated to developers and dashboard creators, either through existing DHIS2 Academies or for example by creating interactive tutorials inside DHIS2.
- Implement more display media that is appropriate for dashboards and possibly remove unnecessary ones after dashboard creators learn which choices are most useful. These needs to be flexible, but not too overwhelming for the average user.
- Implement a feature that allows users to create template dashboards. Taking the EOC routine data dashboard as an example: A user should be able to create a template dashboard where he can filter the content based on a disease. This means the component on the dashboard should be the same, but the data changes and automatically fills the components with relevant data for the chosen disease. This would overall be a useful feature not only for IDSR.
- When a new clean DHIS2 instance is set up it contains no data. HISP UiO is working together with WHO to try to standardise "content" like indicators so that they will be the same or at least similar across DHIS2 instances. This also builds upon what was discussed during the DHIS2 expert meeting: some users don't know how to act upon the data that is shown and one of the reasons for this is that indicators are not standardised and they do not know how to check what the indicator is. The interactive dashboard tries to solve this by giving easy access to indicator information without having the user leave the dashboard. The point being that standardising more things in DHIS2 might be something that can improve evidence based decision making.

7. CONCLUSIONS

Generalising from a case study can be difficult, and in fact is what the case study research method has been criticised for (Flyvbjerg, 2006). The research question of this thesis is the following:

- Can improved dashboard design facilitate improved evidence based decision making in public health for developing countries?

To which I could answer "yes it can, but will it?". In this thesis, guidelines for better dashboard design has been identified and tested on a small scale. People like Stephen Few[21] and Edward Tufte[22] has worked with data visualization for many years and though it is not specifically in public health or user created dashboards they have much experience and we should build upon their work. Talking about design should not go without mentioning Donald Norman[23] and the work he has done, but this is a whole domain itself. The suggested dashboard design guidelines for user created dashboards in Table 6-1 builds upon the guidelines identified in Table 2-3. These are based on earlier research that has been conducted and this thesis shows that they are relevant for the public health context as well.

[21] http://www.perceptualedge.com/about.php

[22] https://en.wikipedia.org/wiki/Edward_Tufte

[23] http://www.jnd.org/about.html

From this case study, I cannot say that these guidelines alone will improve evidence based decision making, but they can help create better dashboards, which will facilitate improved evidence based decision making. Through HISP UiOs network of actions these guidelines should be refined and tested on a bigger scale. The guidelines are just a piece of the puzzle, they also need to be adopted and used to provide any improvements. Another thing to mention is that the users of a dashboard need to know how to act on the presented data.

What makes the guidelines for user created dashboard harder to use is that for tailored dashboards you might have fewer users or at least a narrower scope. It might be easier to directly communicate and work together with the users to create the best dashboard that will fit their exact needs. On the other hand, for the user created dashboards there are different scopes and projects and many possible users with different needs. I would argue that the "target audience" guideline is the most important one, because if the dashboard is not in line with what the users want and need, it won't be used. This goes back to what is both a strength and a weakness with DHIS2, it is flexible and can be customized for all kinds of data collection, but the data output options still requires a lot of work to be done, both in terms of flexibility and features. One of the reasons that this is not straight forward thing to do is that some things might work for some users while not for others, which makes it harder to decide if it should be implemented or not. This is where it could be beneficial to separate users into experts and less experienced user and display different options for each of the user types, but this will require a lot of work and might use time that the developers don't have. DHIS2s Jira platform[24] is where anyone can log in and submit bugs and feature requests and there is a lot of work to do as evident by all the open issues.

The EOC dashboard is a tailored dashboard for specific users and a specific purpose. The purpose might be the same across multiple countries: addressing IDSR output data, but the users might not always be a dedicated EOC. The dashboard should be further developed according to the specification of the EOC in Uganda, while still trying to make smart development choices that can keep it generic and reusable for other IDSR users from other countries. When a fully function prototype of the EOC dashboard has been developed, it should be tested at the EOC in Uganda.

It is hard to say if the guidelines will help with improved evidence based decision making. They can help with improving dashboards which will facilitate better use of evidence based decision making.

[24] https://jira.dhis2.org

7.1 Further Research and Development

EOC Dashboard

The EOC dashboard needs to be further developed and tested in accordance with the dashboard design guidelines. There are a lot of features to be implemented before it can be used as part of a fully functioning IDSR system and tested for usefulness in evidence based decision making. I would say that the biggest factor here is how much developers communicate with the users to tailor the best possible solution for them will affect how widely used it will be for evidence based decision making in IDSR.

DHIS2 Dashboard

The DHIS2 dashboards needs to implement more features for better data output. The suggested guidelines for developers and dashboard creators need to be refined, tested and spread so that people can use them to create better dashboards. Going forward it might be in everyone's best interest to develop more EOC dashboard features directly into the DHIS2 core as it is strengthened into an IDSR system.

REFERENCES

Abela, A. (2009). Chart Suggestions - A Thought-Starter. Retrieved from http://extremepresentation.typepad.com/files/choosing-a-good-chart-09.pdf

African Health Observatory. (2016). *Uganda: Factsheets of Health Statistics 2016* Retrieved from http://www.aho.afro.who.int/profiles_information/images/f/fb/Uganda-Statistical_Factsheet.pdf

Asif. (2016). 10 Remarkable Principles To Design Informative Dashboards. Retrieved from http://blogs.quovantis.com/ten-remarkable-principles-to-design-informative-dashboards/

Avison, D. E., Lau, F., Myers, M. D., & Nielsen, P. A. (1999). Action research. *Communications of the ACM, 42*(1), 94-97. doi:10.1145/291469.291479

Blaschke, S. (2010). Pilotitis in Uganda: mHealth mapping. Retrieved from https://www.flickr.com/photos/texttochange/5178727492/

Blaschke, S. (2012, 03.12). Improving Health Services through Increased Accountability: mTrac and U-Report. Retrieved from https://groups.google.com/forum/ -!msg/ict4chw/wUWyLWkd0TM/ECvqKPpCMlUJ

Borden, P. (2015). The 5 Principles of Great Dashboard Design. Retrieved from http://blog.sumall.com/journal/5-principles-great-dashboard-design.html

Braa, J., & Sahay, S. (2013, 25.03). The Process of Developing the DHIS. Retrieved from https://www.mn.uio.no/ifi/english/research/networks/hisp/hisp-history.html

Braa, K., & Nielsen, P. (2015). *Sustainable Action Research: The Networks of Actions Approach*. Paper presented at the 13th International Conference on Social Implications of Computers in Developing Countries, Negombo, Sri Lanka. https://www.researchgate.net/publication/277014619_Sustainable_Action_Research_The_Networks_of_Actions_Approach

Center for Disease Control and Prevention. (n.d.). Global Health Security: International Health Regulations (IHR). Retrieved from http://www.cdc.gov/globalhealth/healthprotection/ghs/ihr/

Cheng, C. K., Ip, D. K., Cowling, B. J., Ho, L. M., Leung, G. M., & Lau, E. H. (2011). Digital Dashboard Design Using Multiple Data Streams for Disease Surveillance With Influenza Surveillance as an Example. *J Med Internet Res, 13*(4), e85. doi:10.2196/jmir.1658

Davidson, R. M., Martinsons, M. G., & Kock, N. (2004). Principles of Canonical Action Research. *Information Systems Journal, 14*(1), 65-86. doi:10.1111/j.1365-2575.2004.00162.x

DHIS2 Documentation Team. (2017a, 20.02). DHIS2 Implementer Guide. Retrieved from https://docs.dhis2.org/2.26/en/implementer/html/dhis2_implementation_guide_full.html

DHIS2 Documentation Team. (2017b, 20.02). DHIS2 User Guide. Retrieved from https://docs.dhis2.org/2.26/en/user/html/dhis2_user_manual_en_full.html

Easterbrook, S., Singer, J., Storey, M.-A., & Damian, D. (2008). Selecting empirical methods for software engineering research *Guide to advanced empirical software engineering* (pp. 285-311). London: Springer.

eHealth Africa. (2016, 18.01). Lessons From The Field For eHA Program Designers. Retrieved from http://www.ehealthafrica.org/latest/2016/1/18/lessons-from-the-field-for-eha-program-designers

eHealth Africa. (n.d.). EOC Dashboard. Retrieved from http://ehealthafrica.github.io/case-studies/eoc-dashboard.html

Elias, M., & Bezerianos, A. (2011). Exploration Views: Understanding Dashboard Creation and Customization for Visualization Novices. In P. Campos, N. Graham, J. Jorge, N. Nunes, P. Palanque, & M. Winckler (Eds.), *Human-Computer Interaction – INTERACT 2011: 13th IFIP TC 13 International Conference, Lisbon, Portugal, September 5-9, 2011, Proceedings, Part IV* (pp. 274-291). Berlin, Heidelberg: Springer Berlin Heidelberg.

Few, S. (2013). *Information Dashboard Design: Displaying data for at-a-glance monitoring* (2nd ed.). Burlingame: Analytics Press.

Few, S. (2016). Graph Selection Matrix. Retrieved from http://www.perceptualedge.com/articles/misc/Graph_Selection_Matrix.pdf

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry, 12*(2), 219-245. doi:doi:10.1177/1077800405284363

Foldy, S. L., Biedrzycki, P. A., Baker, B. K., Swain, G. R., Howe, D. S., Gieryn, D., . . . Pemble, K. R. (2004). The public health dashboard: a surveillance model for bioterrorism preparedness. *Journal of Public Health Management and Practice, 10*(3), 234-240.

Grammel, L., Tory, M., & Storey, M. A. (2010). How Information Visualization Novices Construct Visualizations. *IEEE Transactions on Visualization and Computer Graphics, 16*(6), 943-952. doi:10.1109/TVCG.2010.164

Heer, J., van Ham, F., Carpendale, S., Weaver, C., & Isenberg, P. (2008). Creation and Collaboration: Engaging New Audiences for Information Visualization. In A. Kerren, J. T. Stasko, J.-D. Fekete, & C. North (Eds.), *Information Visualization: Human-Centered Issues and Perspectives* (pp. 92-133). Berlin, Heidelberg: Springer Berlin Heidelberg.

Kang, J. (2011). Data Visualization and Interface Design for Public Health Analysis: The American Hotspots Project. *Parsons Journal for Information Mapping, 3*(2).

Kavuma, R. M. (2009). Uganda's healthcare system explained. *The Guardian*. Retrieved from https://www.theguardian.com/katine/2009/apr/01/uganda-healthcare-system-explained

Kwapien, A. (2016). 10 Dashboard Design Principles That Will Make Your Data Analysis Worth The Effort. Retrieved from http://www.datapine.com/blog/dashboard-design-principles-and-best-practices/

Lechner, B., & Fruhling, A. (2014). *Towards Public Health Dashboard Design Guidelines.* Paper presented at the HCI International 2014.

Levy, E. (2017). 4 Design Principles for Creating Better Dashboards. Retrieved from https://www.sisense.com/blog/4-design-principles-creating-better-dashboards/

Mellon Training (Producer). (2016). Excel Dashboards: Design Principles & 10 Golden Rules. [Video] Retrieved from https://www.youtube.com/watch?v=TDTka5fGzmI

Monsey, M., & Sochan, P. (n.d.). 10 Principles of Great Dashboard Design With Tableau. Retrieved from http://www.dummies.com/programming/big-data/big-data-

visualization/10-principles-of-great-dashboard-design-with-tableau/

Morgan, M. B., Branstetter, B. F., Lionetti, D. M., Richardson, J. S., & Chang, P. J. (2008). The Radiology Digital Dashboard: Effects on Report Turnaround Time. *Journal of Digital Imaging, 21*(1), 50-58. doi:10.1007/s10278-007-9008-9

Nsubuga, P., Perry, H., Embrey, K., Duale, S., Yada, A., Da Silveira, F., . . . Habimana, P. (2010). *Technical Guidelines for Integrated Disease Surveillance and Response in the African Region* (pp. 400). Retrieved from http://www.cdc.gov/globalhealth/healthprotection/idsr/pdf/technicalguidelines/idsr-technical-guidelines-2nd-edition_2010_english.pdf

O'Sullivan, D. (2016). 6 Steps to Designing Better Dashboards. Retrieved from http://blog.invisionapp.com/designing-better-dashboards/

RapidPro. (n.d.). mTrac. Retrieved from https://community.rapidpro.io/stories/mtrac/

Salesforce. (2013, 18.12). The Nine Principles of Killer Dashboards. Retrieved from http://www.slideshare.net/Salesforce/the-nine-principles-of-killer-dashboards/

Schooley, B., Hilton, B., Abed, Y., Lee, Y., & Horan, T. (2011). *Process Improvement and Consumer-Oriented Design of an Inter-Organizational Information System for Emergency Medical Response.* Paper presented at the 44th Hawaii International Conference on System Sciences, Hawaii.

Sedig, K., & Ola, O. (2014). The challenge of big data in public health: an opportunity for visual analytics. *Online journal of public health informatics, 5*(3). Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3959916/

Shneiderman, B., Plaisant, C., & Hesse, B. W. (2013). Improving Healthcare with Interactive Visualization. *Computer, 46*(5), 58-66. doi:10.1109/MC.2013.38

Sopan, A., Noh, A. S.-I., Karol, S., Rosenfeld, P., Lee, G., & Shneiderman, B. (2012). Community Health Map: A geospatial and multivariate data visualization tool for public health datasets. *Government Information Quarterly, 29*(2), 223-234. doi:10.1016/j.giq.2011.10.002

Stake, R. E. (2005). Qualitative Case Studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of Qualitative Research* (pp. 443-466). Thousan Oaks, CA: Sage Publications.

Taylor, T. (2016, 30.10). What You Need to Know About Designing Information Dashboards. Retrieved from https://speckyboy.com/designing-information-dashboards/

Toddenroth, D., Sivagnanasundaram, J., Prokosch, H.-U., & Ganslandt, T. (2016). Concept and Implementation of a Study Dashboard Module for a Continuous Monitoring of Trial Recruitment and Documentation. *Journal of Biomedical Informatics, 64*, 222-231.

United Nations Development Programme. (2014, 13.10). Uganda gets a National Emergency Coordination and Operations Centre for Disaster preparedness. Retrieved from http://www.ug.undp.org/content/uganda/en/home/presscenter/articles/2014/10/13/uganda-gets-a-national-emergency-coordination-and-operations-centre-for-disaster-preparedness.html

Viegas, F. B., Wattenberg, M., Ham, F. v., Kriss, J., & McKeon, M. (2007). ManyEyes: a Site for Visualization at Internet Scale. *IEEE Transactions on Visualization and Computer Graphics, 13*(6), 1121-1128. doi:10.1109/tvcg.2007.70577

APPENDIX A

Uganda Proposed IDSR system

eIDSR

Electronic Integrated Disease Surveillance and Response

Proposed

...surveillance system that detects and manages outbreaks…

Specific goals of IDSR: WHO AFRO

- To strengthen district-level surveillance and response for priority diseases
- To integrate surveillance with laboratory support
- To translate surveillance and laboratory data into specific public health actions

http://www.who.int/csr/labepidemiology/en/IDSNews.pdf

[MOH PHEOC - Health Alert System] Confirmed Rubella outbreak in Serere district Inbox x

MOH PHEOC - Health Alert Syste 12:40 PM (21 hours ago)

to

Five serum specimen were collected from five suspect measles patients from Kateta and Bugondo sub-counties of Serere district on 1Nov16. None of these tested Measles positive on IgM, but four of them tested positive for Rubella on IgM, thus confirming a Rubella outbreak in the district.

- Who are the cases?
- What were the symptoms?
- What is their residence?
- What's their status (Alive/Dead)?

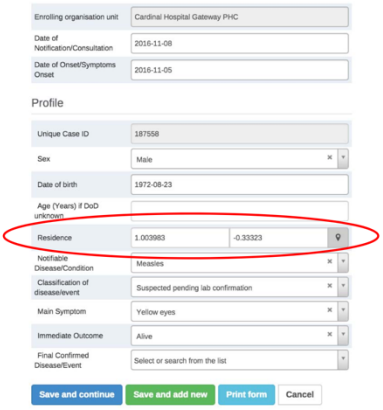
- What specimen were collected?
- What tests were done?
- When were the tests done?

- What specimen?
- When did the outbreak start?
- How many more cases were and being registered?

Is all this data in a database?

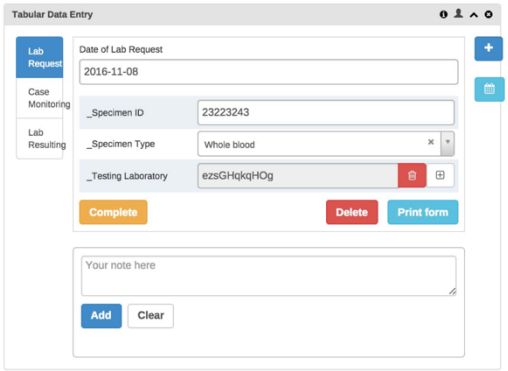
Source: Uganda Ministry of Health EOC Health Alert System

Collection of Data – Case notification



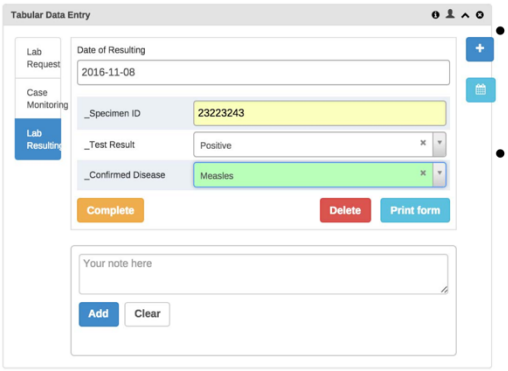
- Register a case and notify relevant authorities
- Capture residential coordinates

Lab confirmation– Lab Request



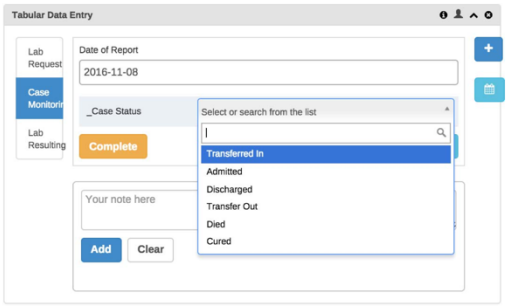
- Request for lab testing
- Notify the Lab and relevant authorities

Lab confirmation– Lab Resulting



- Enter ONLY relevant lab results
- Notify the relevant authorities

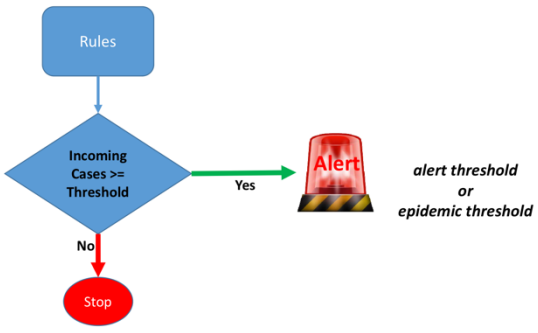
Case Monitoring



- Update the status of the case
- Notify the relevant authorities

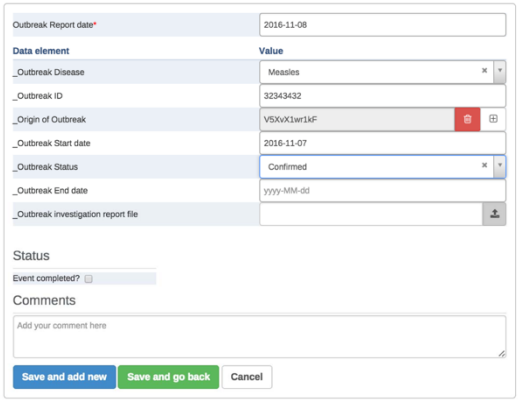
Outbreak Detection

- Aggregate cases
- Thresholds and Algorithms



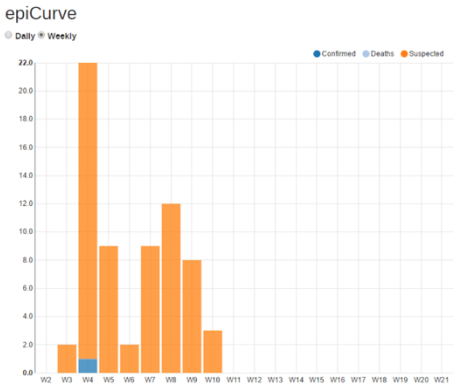
Outbreak Management

- When the outbreak started
- Started from where
- Upload Outbreak report



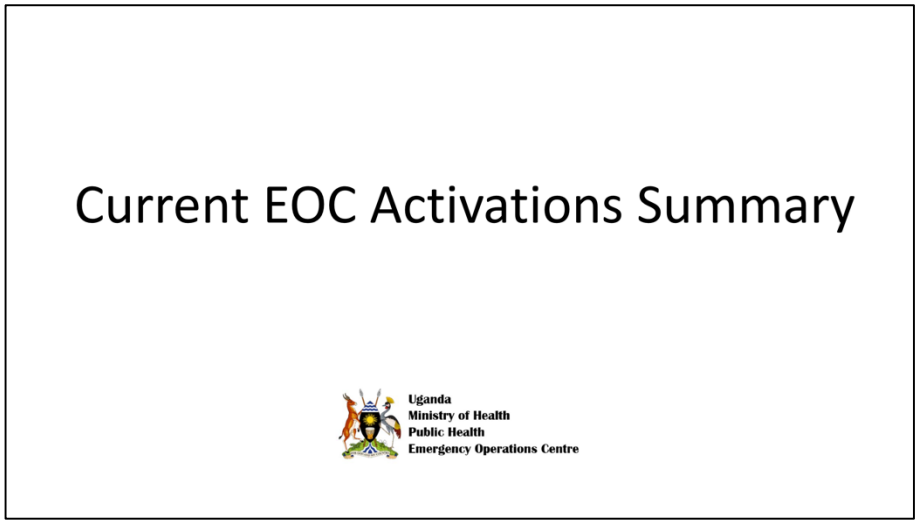
Outbreak Monitoring

- Line lists and Epi-Curve
- Dynamic and live Dashboards



APPENDIX B

EOC Daily Slides



PHEOC ACTIVATIONS SUMMARY

PUBLIC HEALTH EVENT	LOCATION	DATE	PHEOC STATUS
Rift Valley Fever Outbreak	Kabale District	11 Mar 2016	Response Mode
Malaria outbreak -	Northern Uganda	6 Jul 2015	Response Mode
eMTCT HIV	Nationwide	Jun 2013	Response Mode

PHEOC ALERTS SUMMARY

PHE	LOCATION	DATE	EOC STATUS
Measles	Kamwenge, Kamuli	5Jul16	ALERT
Rubella	Hoima, Alebtong, Kween	30Jun16	ALERT
Cholera	Amuru, Adjumani, Yumbe	15Aug16	ALERT
Refugees Influx	Zombo, Arua, Kiryandongo, Yumbe, Adjumani	1Jul16	ALERT

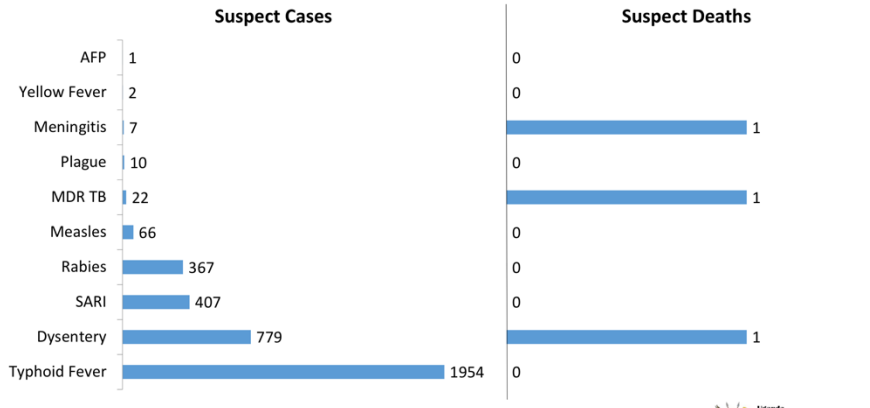
PHEOC INTERNATIONAL ALERTS SUMMARY

Event and Location	PHEOC Status	Date
Wild Poliovirus, Nigeria	ON WATCH	Aug 16
H1N1, H5N6, H7N3 Avian Influenza - China, Mexico, Indonesia, Niger	ON WATCH	Jan16
Lassa Fever Outbreak - Nigeria and Benin	ON WATCH	Mar16
Crimean - Congo Hemorrhagic Fever - Pakistan	ON WATCH	Aug16
Anthrax outbreak - Bangladesh, Zambia, Kenya, Russia, India, France	ON WATCH	May 16
Cholera, Measles - South Sudan	ON WATCH	Jul16
Chikungunya - Kenya	ON WATCH	Aug16
Yellow Fever - DRC, Ghana, Angola	ON WATCH	Jan16
Zika Virus - Multiple Countries	ON WATCH	Dec15

Weekly IDSR Weekly Surveillance Summary

Uganda
Ministry of Health
Public Health
Emergency Operations Centre

Uganda IDSR Weekly Surveillance Priority Diseases and Conditions for Wk36



Source: National eHMIS system. Reported Cases and deaths have to be verified

Uganda
Ministry of Health
Public Health
Emergency Operations Centre

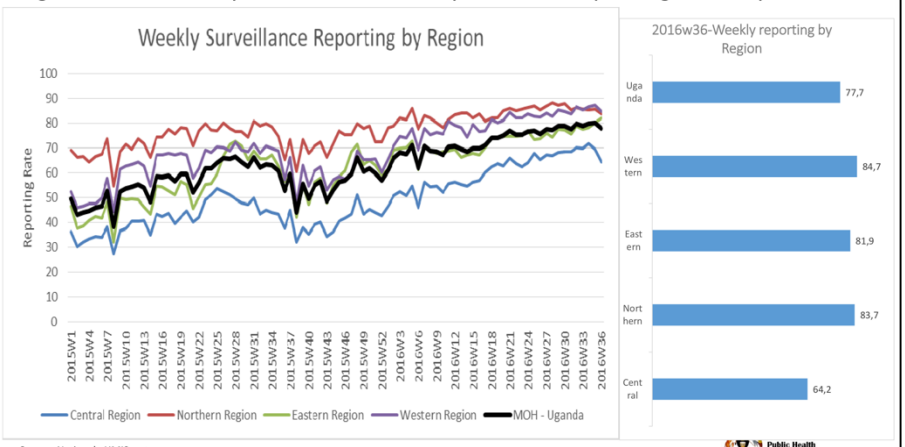
Location of the notifiable conditions Reported in Wk36

District	Facility	Bacteria Meningitis	Plague	Yellow Fever	MDR TB
Bundibugyo	Kikyo HC IV	1			
Busia	Dabani General Hospital	1			
Gulu	St. Mary's Lacor General Hospital	2			
Jinja	TASO Jinja CLINIC HC II				12
Kabarole	Fort Portal RR Hospital	2			
Kasese	Buthale HC II		1		
Kibaale	Betania - Kasenyi HC II			2	
Kibaale	St Marys Kakindo HC III		10		
Kitgum	Kitgum General Hospital				2
Koboko	Koboko General Hospital				4
Kotido	Lokitelaebu HC III				1
Nwoya	Koch Lii HC II				1
Pader	Acholi-Bur HC III				1
Tororo	St. Anthony'S Tororo General Hospital				1
Zombo	Nyapea General Hospital	1			

Source: National eHMIS system. Reported Cases and deaths have to be verified

Uganda
Ministry of Health
Public Health
Emergency Operations Centre

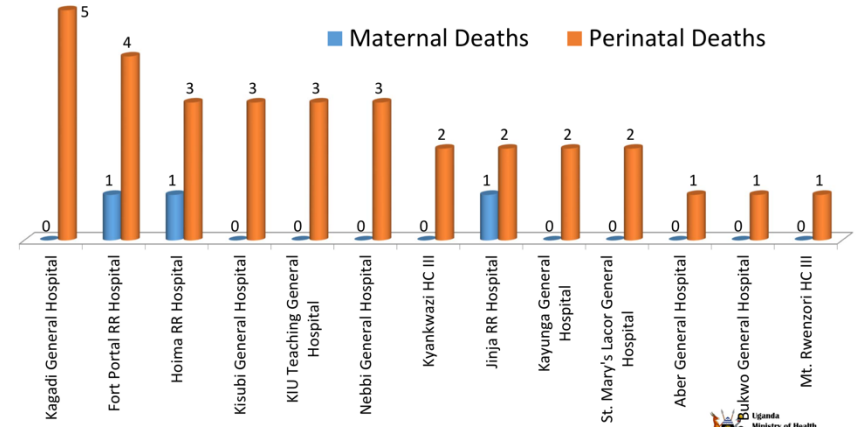
Uganda IDSR Weekly Surveillance Priority Diseases Reporting Rates by Wk36



Source: National eHMIS system

Public Health Emergency Operations Centre

Uganda IDSR Weekly maternal and perinatal deaths for EpiWk 36



Source: National eHMIS system. Reported Cases and deaths have to be verified

Uganda Ministry of Health Public Health Emergency Operations Centre

Public Health Events Uganda

Uganda
Ministry of Health
Public Health
Emergency Operations Centre

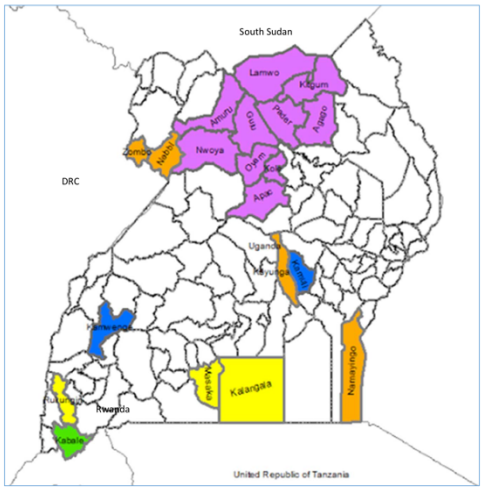
Current Uganda Disease Outbreaks

July 18, 2016

Legend

- Rift Valley Fever
- Cholera
- Malaria
- Yellow Fever
- Measles

Uganda
Ministry of Health
Public Health
Emergency Operations Centre



Refugees Influx from S. Sudan to N. Uganda

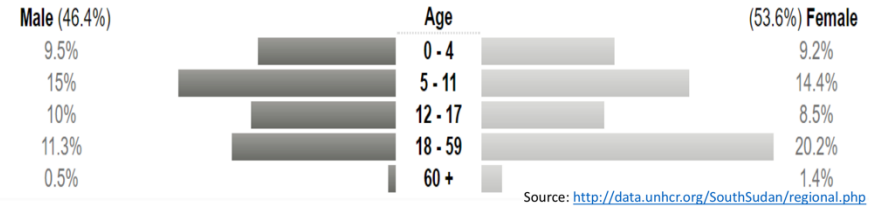
Update as of 16Sep16

Uganda
Ministry of Health
Public Health
Emergency Operations Centre

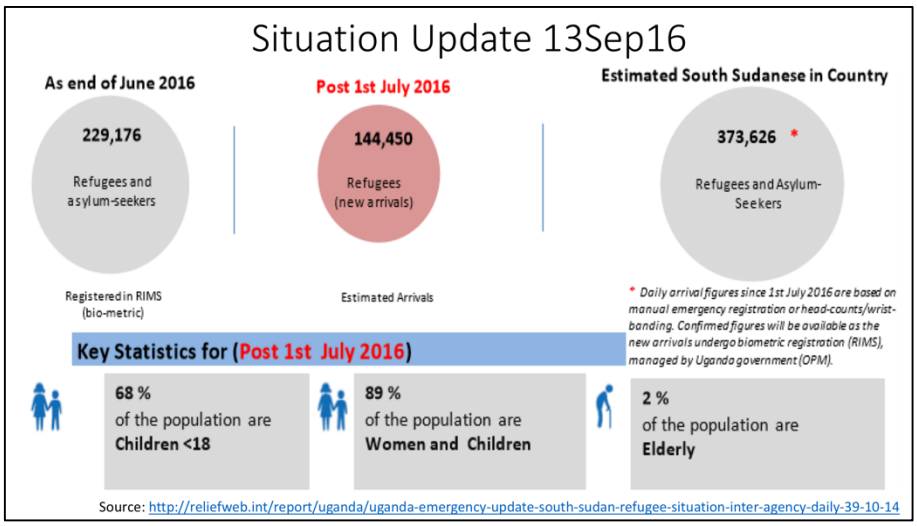
Key Situation Statistics

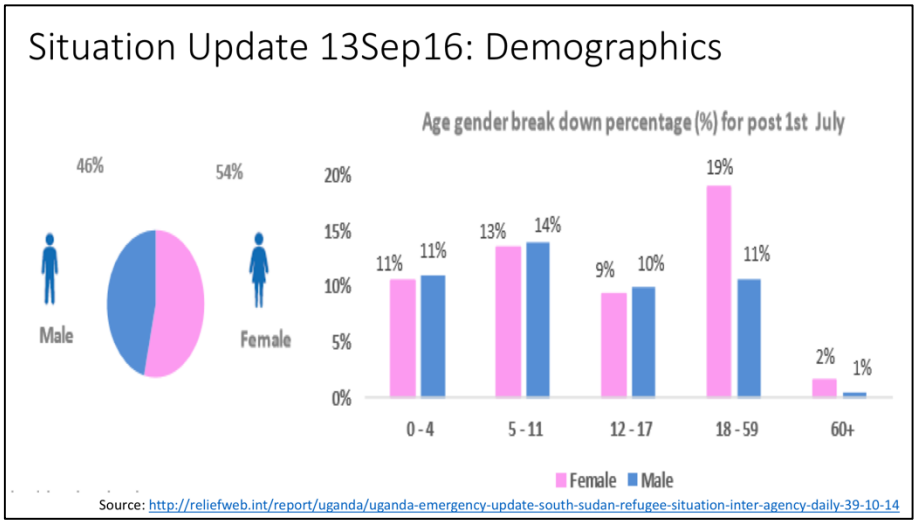
- Refugees from South Sudan Post 15 Dec 2013: **904,740**
- Refugees and asylum-seekers from South Sudan Pre 15 Dec 2013: **115,013**
- Refugees and asylum-seekers from South Sudan: **1,019,753**

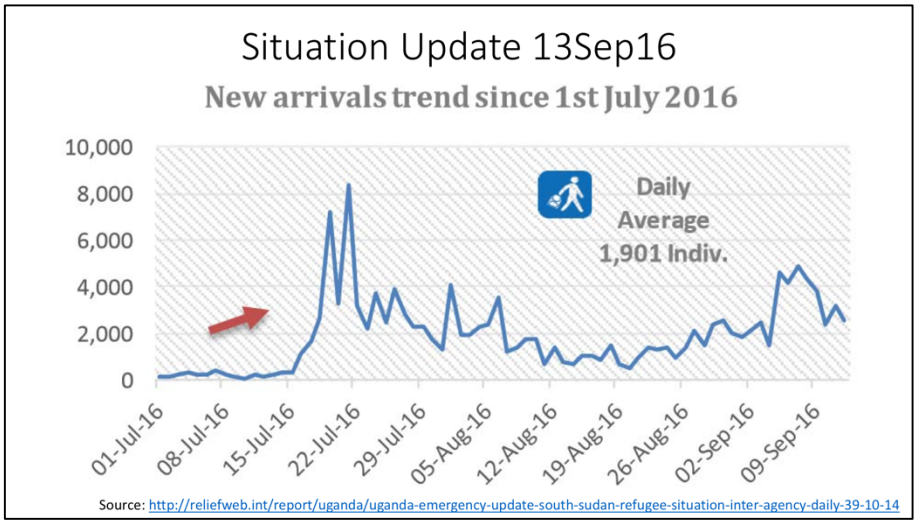
Demography



Source: http://data.unhcr.org/SouthSudan/regional.php


Situation Update 13Sep16
As end of June 2016
229,176
Refugees and asylum-seekers
Registered in RIMS (bio-metric)
Post 1st July 2016
144,450
Refugees (new arrivals)
Estimated Arrivals
Estimated South Sudanese in Country
373,626 *
Refugees and Asylum-Seekers
* Daily arrival figures since 1st July 2016 are based on manual emergency registration or head-counts/wrist-banding. Confirmed figures will be available as the new arrivals undergo biometric registration (RIMS), managed by Uganda government (OPM).
Key Statistics for (Post 1st July 2016)
68 % of the population are Children <18
89 % of the population are Women and Children
2 % of the population are Elderly
Source: http://reliefweb.int/report/uganda/uganda-emergency-update-south-sudan-refugee-situation-inter-agency-daily-39-10-14


Situation Update 13Sep16: Demographics
Age gender break down percentage (%) for post 1st July
46%
54%
Male
Female
20%
15%
10%
5%
0%
11%
11%
13%
14%
9%
10%
19%
11%
2%
1%
0-4
5-11
12-17
18-59
60+
Female
Male
Source: http://reliefweb.int/report/uganda/uganda-emergency-update-south-sudan-refugee-situation-inter-agency-daily-39-10-14

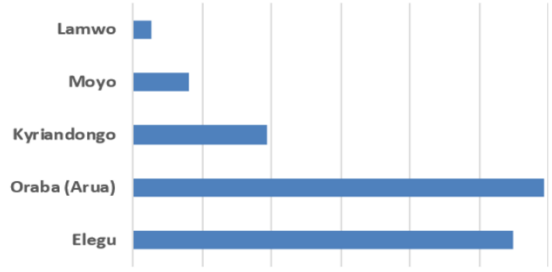

Situation Update 13Sep16
New arrivals trend since 1st July 2016
10,000
8,000
6,000
4,000
2,000
0
Daily Average 1,901 Indiv.
01-Jul-16
08-Jul-16
15-Jul-16
22-Jul-16
29-Jul-16
05-Aug-16
12-Aug-16
19-Aug-16
26-Aug-16
02-Sep-16
09-Sep-16
Source: http://reliefweb.int/report/uganda/uganda-emergency-update-south-sudan-refugee-situation-inter-agency-daily-39-10-14

Situation Update 13Sep16

Total Arrivals per Month Since 1st July 2016

July	53,531	Oct	Dec
Aug	49,427	Nov	
Sep	41,492		

Location	Total
Elegu	54,834
Oraba (Arua)	59,432
Kyriandongo	19,356
Moyo	8,098
Lamwo	2,730
Total	**144,450**
Post 7 Jul 2016	**143,164**
Since Jan 2016	**178,837**



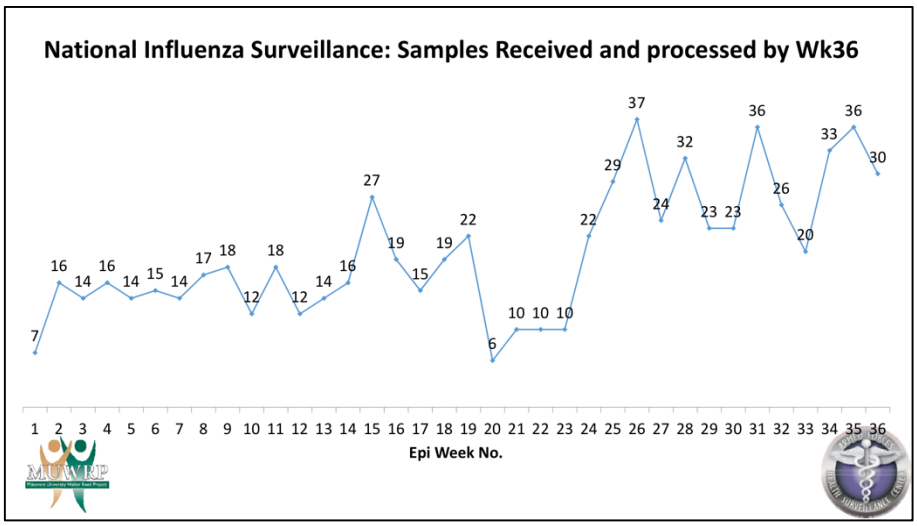
Source: http://reliefweb.int/report/uganda/uganda-emergency-update-south-sudan-refugee-situation-inter-agency-daily-39-10-14

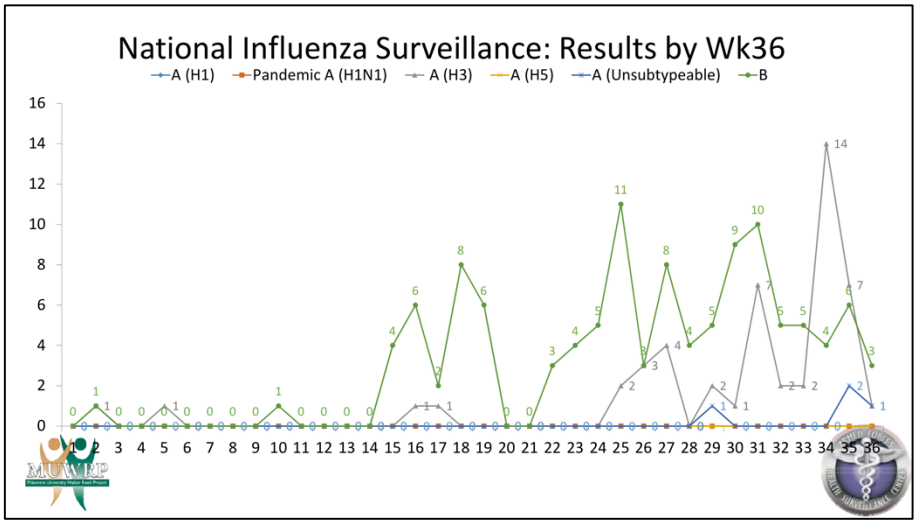
Situation Update 19Sep16

- 5,869 South Sudanese people fled to Uganda between the 16th and 18th September, the vast majority of whom are using border crossing points in to Arua district
- 7,564 refugees were relocated from Adjumani, Arua and Moyo to Bidibidi settlement in Yumbe, bringing the total refugee population in Yumbe to 93,109 refugees.
- In a bid to decongest Ocea Reception Centre, 1,026 individuals were relocated to the newly-opened Ofua village within Rhino Refugee Settlement.
- The motorized water system at Ocea has been repaired, boosting the supply of clean water from seven liters per person per day to ten litres per person per day. A new water tank has also been installed in Ofua village.

Source: http://reliefweb.int/report/uganda/uganda-emergency-update-south-sudan-refugee-situation-inter-agency-daily-41-17th-19th

Uganda National Influenza Surveillance





Cholera Outbreaks Uganda

Uganda
Ministry of Health
Public Health
Emergency Operations Centre

Cholera Outbreak
Adjumani District

Summary as of 20 Sept 2016

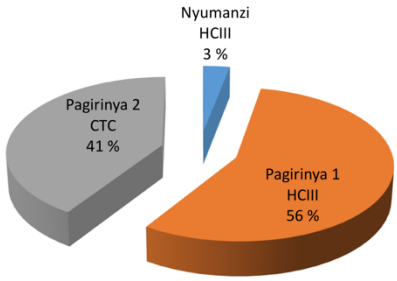
Cholera Outbreak Summary

- First patient was admitted on the 8Sep16
- Cumulatively, a total of 99 cases reported by 20Sep16
  - Two still admitted
  - None dead from Cholera

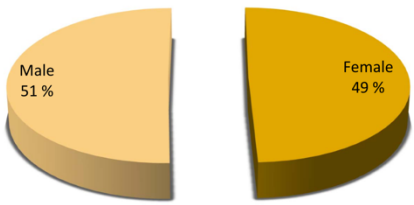
Uganda
Ministry of Health
Public Health
Emergency Operations Centre

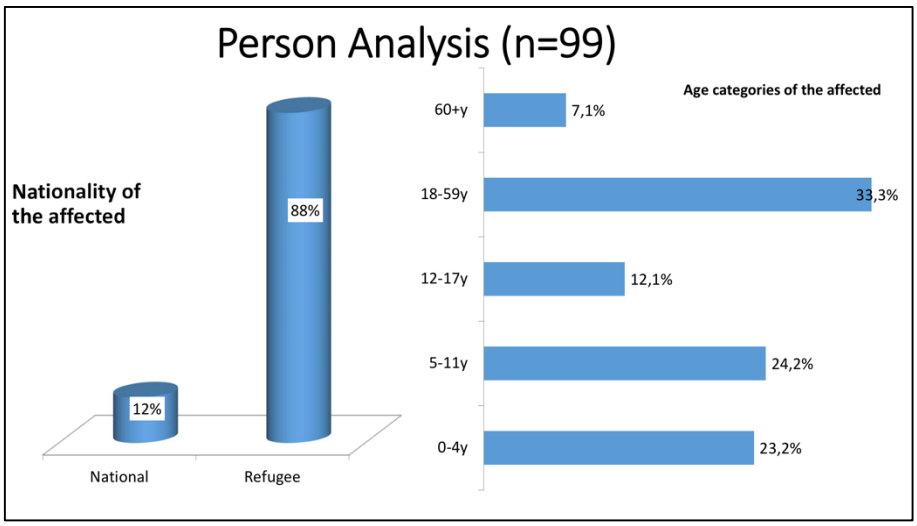
Person Analysis (n=99)

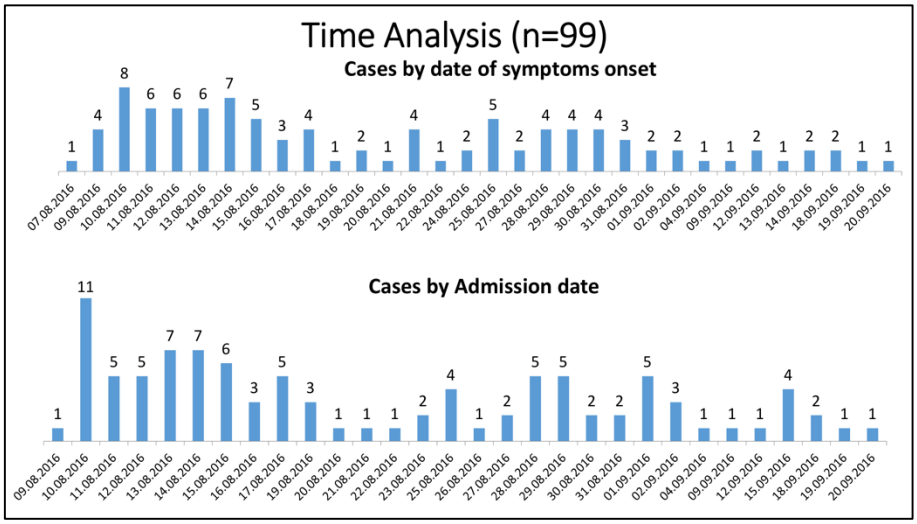
CTC were affected were admitted

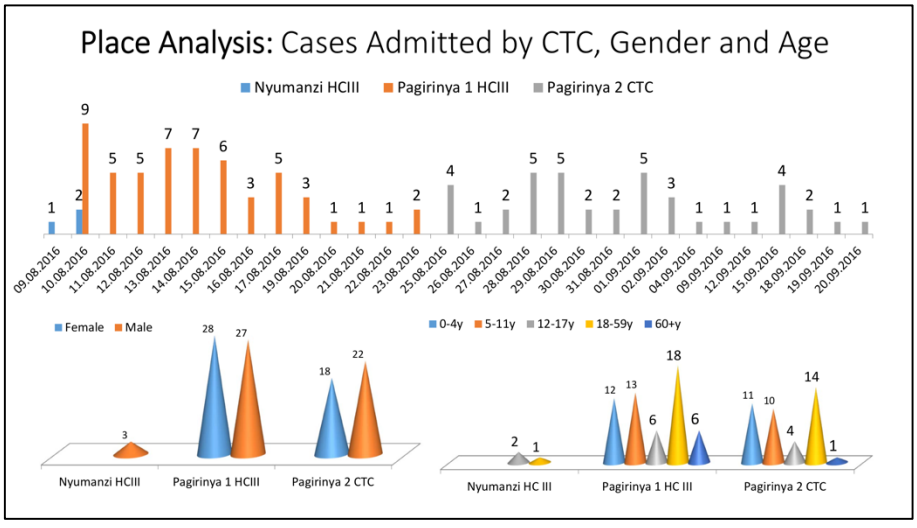


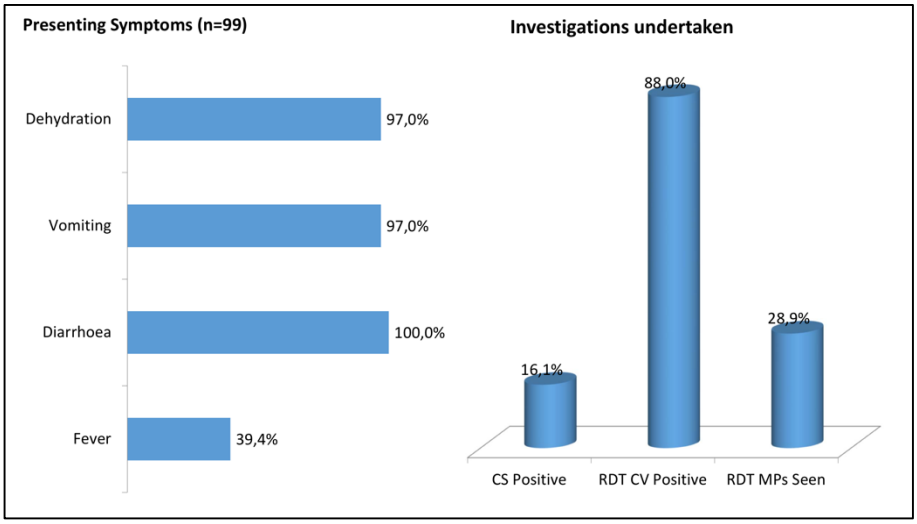
Affected Gender




Person Analysis (n=99)
Nationality of the affected
88%
12%
National
Refugee
Age categories of the affected
60+y
7,1%
18-59y
33,3%
12-17y
12,1%
5-11y
24,2%
0-4y
23,2%


Time Analysis (n=99)
Cases by date of symptoms onset
Cases by Admission date


Place Analysis: Cases Admitted by CTC, Gender and Age
Nyumanzi HCIII
Pagirinya 1 HCIII
Pagirinya 2 CTC
Female
Male
Nyumanzi HCIII
Pagirinya 1 HCIII
Pagirinya 2 CTC
0-4y
5-11y
12-17y
18-59y
60+y
Nyumanzi HC III
Pagirinya 1 HC III
Pagirinya 2 CTC



Cholera Outbreak YumbeDistrict

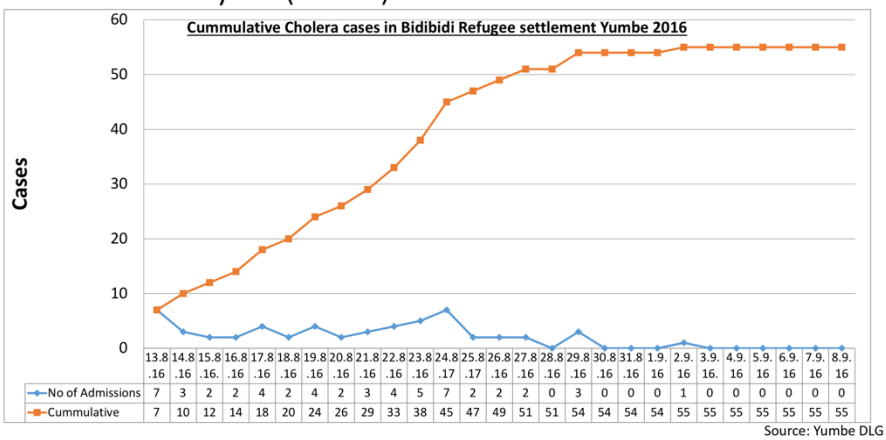
Summary as of 9 Sept 2016

Cholera Outbreak Summary

- First patient was admitted on the 13Aug2016
- Cumulatively, a total of 54 cases reported by 9Sep16
  - All discharged
  - None dead from Cholera

Uganda
Ministry of Health
Public Health
Emergency Operations Centre

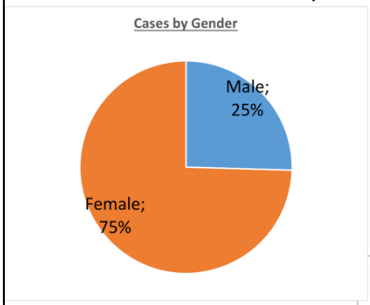
Time Analysis (n=55)

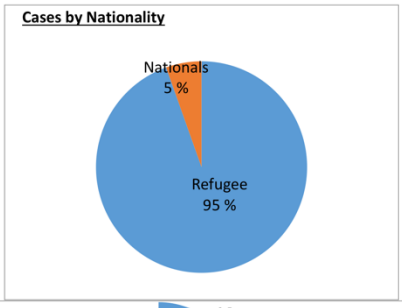


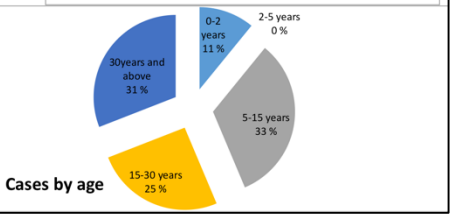
	13.8.16	14.8.16	15.8.16.	16.8.16	17.8.16	18.8.16	19.8.16	20.8.16	21.8.16	22.8.16	23.8.16	24.8.17	25.8.17	26.8.16	27.8.16	28.8.16	29.8.16	30.8.16	31.8.16	1.9.16	2.9.16	3.9.16.	4.9.16	5.9.16	6.9.16	7.9.16	8.9.16
No of Admissions	7	3	2	2	4	2	4	2	3	4	5	7	2	2	2	0	3	0	0	0	1	0	0	0	0	0	0
Cummulative	7	10	12	14	18	20	24	26	29	33	38	45	47	49	51	51	54	54	54	54	55	55	55	55	55	55	55

Source: Yumbe DLG

Person Analysis (n=55)

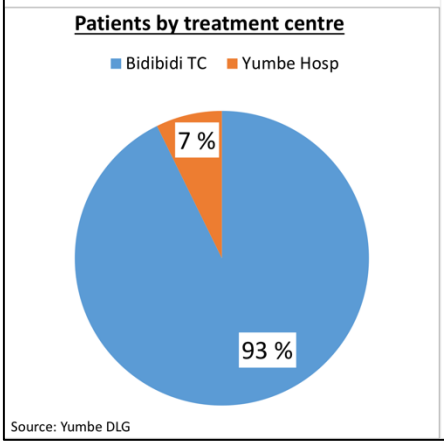




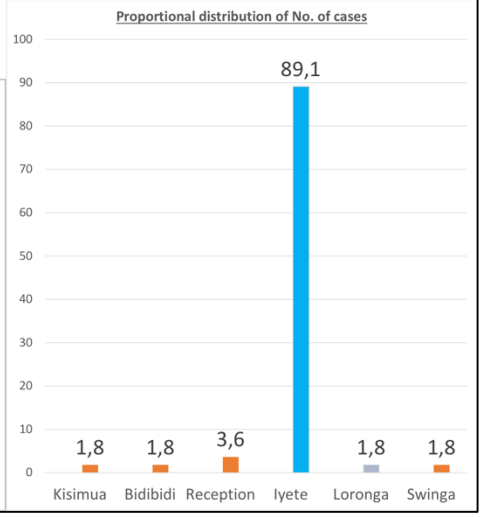


Source: Yumbe DLG

Place Analysis (n=55)

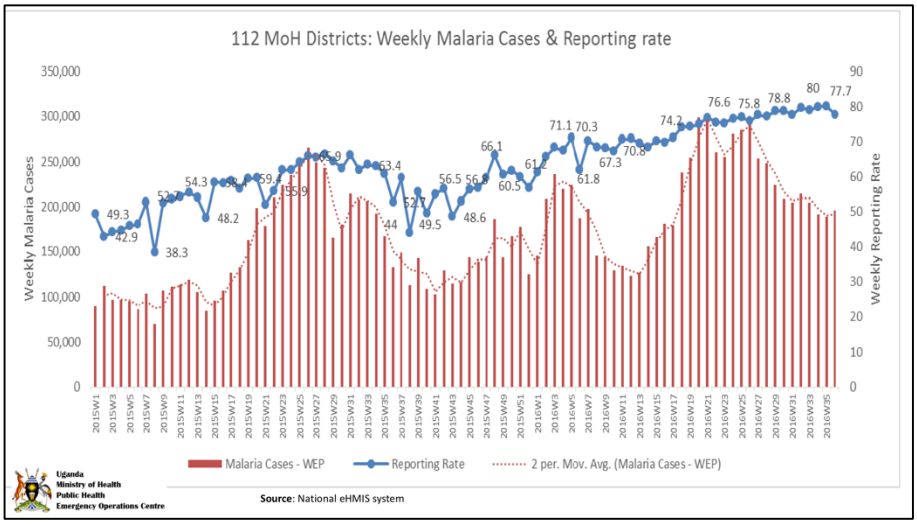


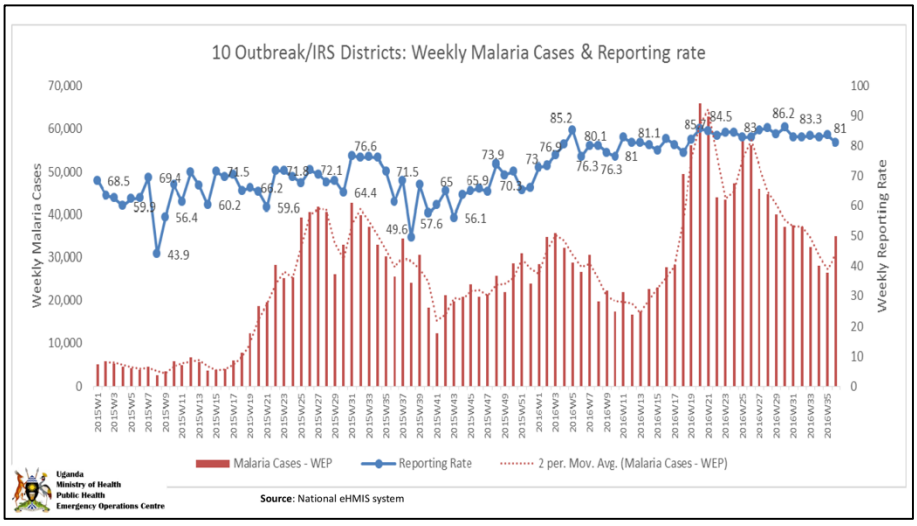
Source: Yumbe DLG

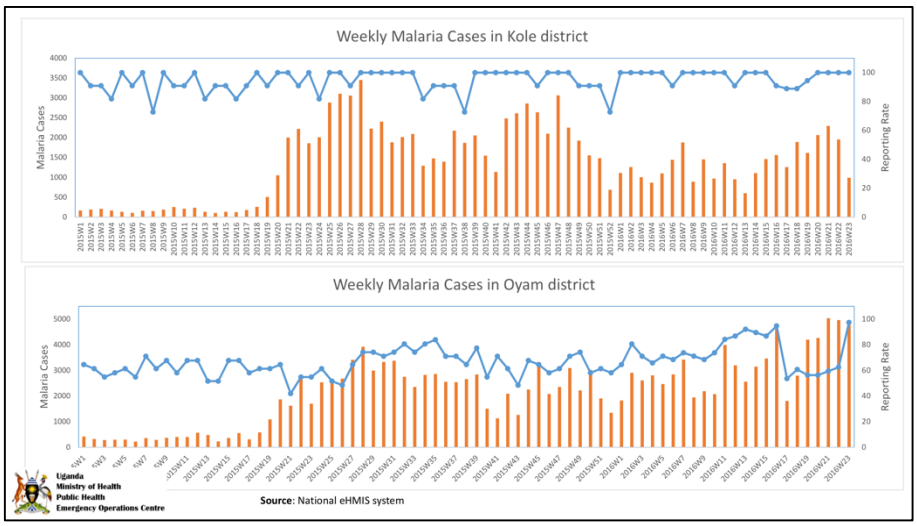


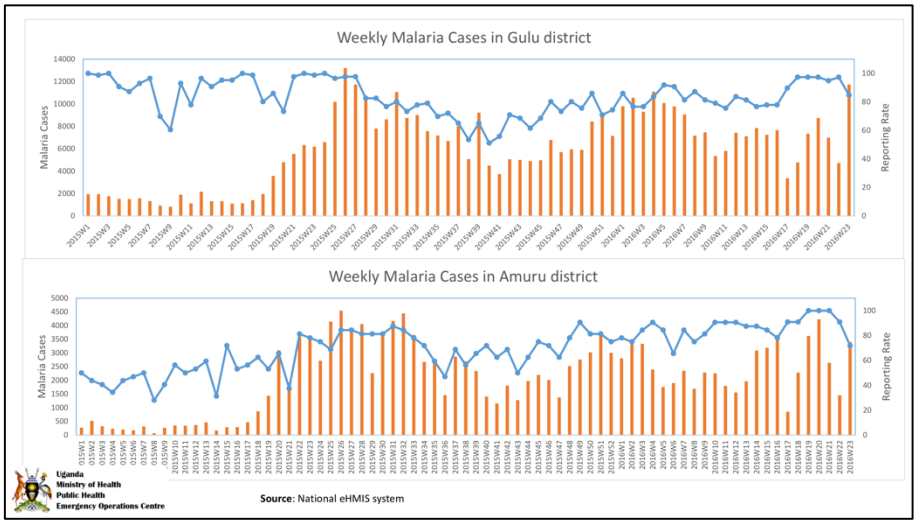
Malaria Outbreak
Northern Uganda – 10 IRS Districts

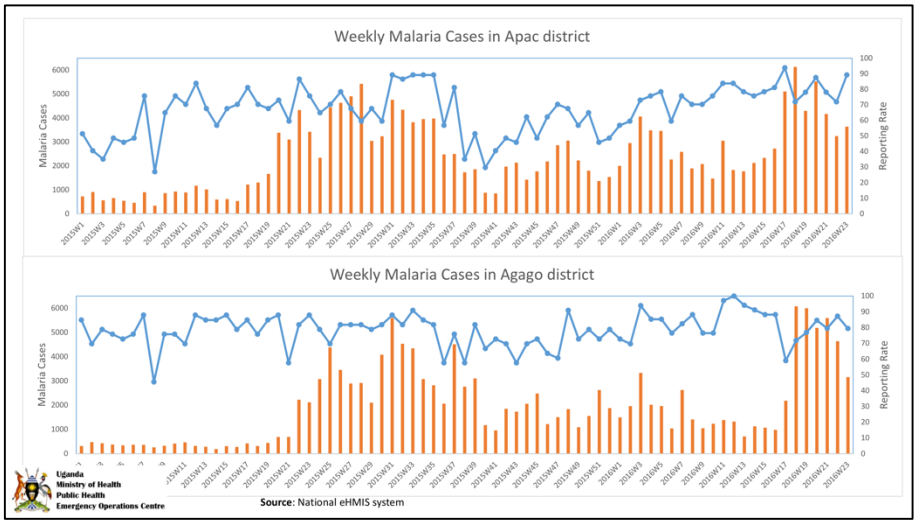
Uganda
Ministry of Health
Public Health
Emergency Operations Centre

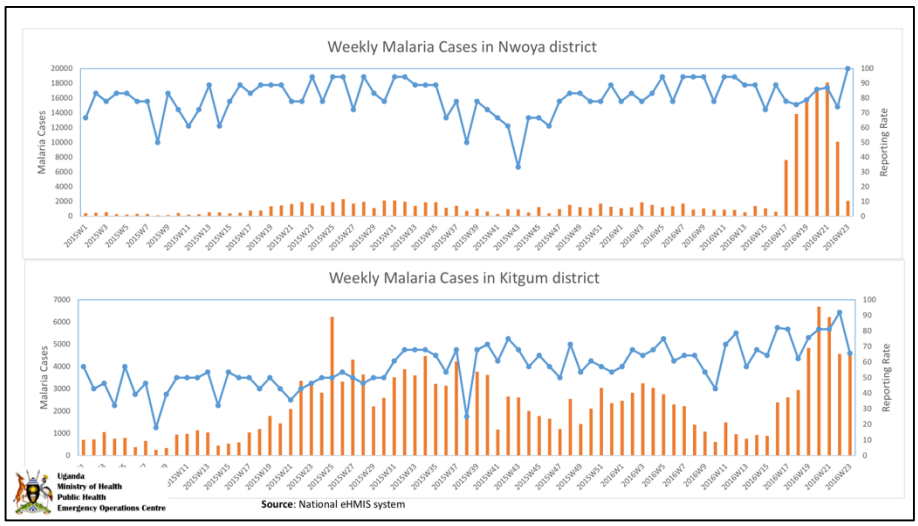


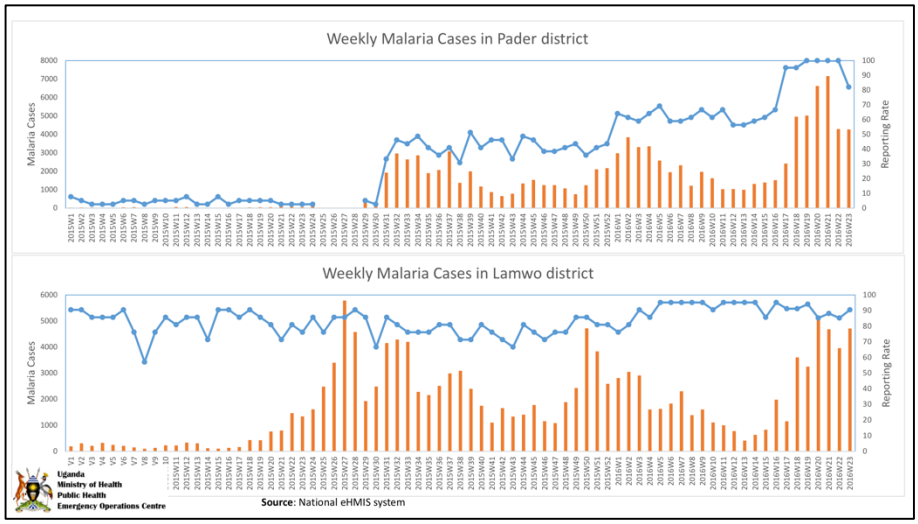



Weekly Malaria Cases in Kole district
Malaria Cases
Reporting Rate
Weekly Malaria Cases in Oyam district
Malaria Cases
Reporting Rate
Uganda
Ministry of Health
Public Health
Emergency Operations Centre
Source: National eHMIS system


Weekly Malaria Cases in Gulu district
Malaria Cases
Reporting Rate
Weekly Malaria Cases in Amuru district
Malaria Cases
Reporting Rate
Uganda
Ministry of Health
Public Health
Emergency Operations Centre
Source: National eHMIS system


Weekly Malaria Cases in Apac district
Malaria Cases
Reporting Rate
Weekly Malaria Cases in Agago district
Malaria Cases
Reporting Rate
Uganda
Ministry of Health
Public Health
Emergency Operations Centre
Source: National eHMIS system


Weekly Malaria Cases in Nwoya district
Malaria Cases
Reporting Rate
Weekly Malaria Cases in Kitgum district
Malaria Cases
Reporting Rate
Uganda
Ministry of Health
Public Health
Emergency Operations Centre
Source: National eHMIS system


Weekly Malaria Cases in Pader district
Malaria Cases
Reporting Rate
Weekly Malaria Cases in Lamwo district
Malaria Cases
Reporting Rate
Uganda
Ministry of Health
Public Health
Emergency Operations Centre
Source: National eHMIS system