ELECTRONIC REGISTRATION IN OUTPATIENT THERAPEUTIC FEEDING PROGRAMS

What electronic tools are appropriate to meet the needs of

outpatient programs of Médecins Sans Frontières?

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Summary

The objective of the research is identification of the existing electronic registration tools for patients in an outpatient Ambulatory Therapeutic Feeding Centres (ATFC). The aim of electronic registration is to replace the register book and to eliminate the use of pen and paper in the registration process. This would result in increased efficiency, higher accuracy of registration and instant data delivery to facilitate decision-making in the project and to feed the data directly into the Health Information System (HIS).

The app or platform facilitating the data collection process in an outpatient setting should be a Mobile Data Collection (MDC) tool using telephones or tablets, and without internet connection. The MDC tool should enable the follow up of patients over a time period, specifically track admission and discharge data, which categorises the tool as Electronic Medical Record (EMR). However, registration in an ATFC requiring simple follow-up of patients is a light version of an EMR (EMR-light).

Mobile Data Collection (MDC) tools have reportedly improved the quality of data, the accuracy, reliability, and timeliness of data collection, aggregation, analysis and reporting. High quality data is the evidence base to improve medical programs, operations, accountability, quality of care and to steer innovation. Besides registration and data collection, MDC tools can also be used for diagnosis and treatment support, identification, and instant follow up to strengthen patient care.

During the current paper based registration and data collection, several data are retrieved retrospectively from the patient cards and manually entered into the register book. In order to make the process more efficient, apps for electronic registration should cover data collection during the entire workflow, implying that several users should be able to work in the app simultaneously in a remote setting. In addition, the devices of users should communicate or share the data with each other instantly e.g. by a portable server or Near Field Communication (NFC). As an alternative, data can be stored and held by the patient on a chip (e.g. an eHealth card). The information on a chip can be used in all apps and workstations and is literally owned by the patient.

Six apps and platforms were evaluated against predefined benchmarks on data requirements and technical functionalities plus feedback from current users and technical tests. In the course of the process other features related to management were reviewed including relation to legal and ethical requirements, management of the app and costing structure. The six apps / platforms evaluated were Survey CTO, CommCare, Dharma, Mango Logic, Easynut and Buendia. The first four are platforms that are in use of NGO's and the latter two are apps were developed specifically for a certain purpose in MSF and both stopped the development.

A platform has many advantages above single apps: a platform will be automatically maintained and serviced and the organisation is supported in a consistent and sustainable way. Several apps can be developed using the same platform, and these apps can therefore be connected , e.g. a nutrition registration app with logistics; or a nutrition app with an app to support diagnosis and treatment (e.g. eCare of OCG), enriching the data collection and

analysis and preventing the same data collected several times. A platform makes apps more cost effective and a platform supports scaling up of electronic data collection.

The platforms Dharma and Mangologic are the most suitable regarding requirements, functionalities, technical tests, users experience, service and cost. Mangologic has already developed apps for similar use in outpatient reproductive health programs and has overcome the initial bugs inherent to building new apps.

However, fast technical developments go and negotiations with the producer can change the cost benefit balance. Consequently, a framework for platforms should be developed including technical features e.g. automatic feed to DHIS2, functions in remote settings, functions at several workstations, supports follow-up of patients.

It is strongly recommended to develop and implement a pilot on a platform for electronic data processes in an outpatient program to evaluate the feasibility and acceptance, the cost-effectiveness of data flows, the management of such a system, the impact on patient care and program management. A pilot would be indispensable for further development of data protection systems (e.g. rules of behaviour). Finally, a pilot would inform further development of a general MSF eHealth strategy in outpatient health programs.

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Contents

Concepts, abbreviations and acronyms

Concept, abbreviation	Explanation
ACF	Action Contre le Faim
API	Application Program Interface
App; application	A digital tool for a specific purpose
ATFC	Ambulatory Therapeutic Feeding Centre
Buendia	OCA EMR for ATFC and ITFC
DHIS2	District Health Information System version 2
eATFC	Electronic registration tool for Ambulatory Therapeutic Feeding Centre
EMR	Electronic Medical Records
GDPR	General Data Protection Regulation
HDPP	Health Data Protection Policy (MSF)
HIPAA	International Patient Record Standard
HIS	Health Information System
HMIS	Hospital Management and Information System
ICRC	International Committee Red Cross
IT department	Information Technology
IMC	International Medical Corps
IMCI	Integrated Management of Childhood Illnesses
ITFC	Inpatient Therapeutic Feeding Centre
MDC tools	Mobile Data Collection tools (software functioning on smartphone or tablet)
MOH	Ministry of Health
MSF	Médecins Sans Frontières
NFC	Near Field Communication
OCA	MSF Operational Centre Amsterdam
OCBA	MSF Operational Centre Barcelona
OCB	MSF Operational Centre Brussels
OCG	MSF Operational Centre Geneva
Platform	Electronic environment on which several apps can be built
SCF	Safe the Children
TfH	Terre des Hommes
TFP	Therapeutic Feeding Program (ITFC and ATFC)
WHO	World Health Organisation
WVI	World Vision International

1. Background

1.1. Introduction

Over the past twenty years, MSF has developed a large number of protocols, tools and standards for both diversified and specialist care. This has led to new requirements in capturing work activities, to ensure and improve quality. Furthermore, the increased numbers of staff and patients treated have created a huge information machine that is mostly based on data gathered with pen and paper. Usually, this process is slow, gives difficulties in tracing back a patient file, and it is sensitive to registration mistakes. The written data from patient cards and registers are later copied to electronic databases. This step also makes the data capturing system slow, sensitive to mistakes and prone to misinterpretation. Most of the data from medical programs are aggregated manually before being analysed and reported.

The entire process of data capturing from patient to report involves tedious manual work, that introduces room for mistakes and delays and is unnecessarily expensive in terms of staff involved and time spent in entering and checking data.

An improvement is the implementation of a more modern system of data processing to replace Excel: the Health Information System (HIS). This is a new system for data entry, visualisation and reporting. The format of data entry changes, and the data are fed in an overall data platform (DHIS2), from where it is automatically processed in a reporting format according to MSF OCA's requirements. However, the step from hand-written patient cards and registers to electronic data entry has not changed much.

To address this, an application for electronic medical records (EMR) was developed in 2016. This EMR, called Buendia, made it possible to electronically register and follow individual patients in the in- and outpatient feeding programs. The objective of the EMR was to make the follow-up of patients more efficient and accurate, to improve treatment quality, and to improve the timely and efficient reporting of program data. Evaluation of the first version of the application showed that the system had a limited capacity to process all data simultaneously: the number of data per patient, the number of simultaneous users, the number of patients combined with instant backups in a context with limited connectivity. As it would require major investments to fix the application, the decision was taken to temporarily stop the development of electronic medical records.

MSF is not the only actor in the humanitarian world attempting to rationalise data flows. In the past few years, other humanitarian organisations working in the domain of nutrition have deployed mobile data collection (MDC) tools to register patients electronically.
In order to advance electronic registration, it would be helpful to explore which electronic registration tools are being used and to identify the pros and cons of every tool.
This research is restricted to electronic registration tools in the outpatient feeding centres, also known as Ambulatory Therapeutic Feeding Centres (ATFC). The electronic tools eligible for examination should be able to eliminate the use of pen and paper in the registration process, to increase efficiency and accuracy of registration, to deliver data instantly to program management to facilitate decision-making, and to feed directly and instantly into the core data capturing system (HIS).
Electronic tools used in ATFC's that are in the periphery (outside the main hospitals) should work on mobile electronic hardware, such as a telephone or tablet, thus restricting the search to Mobile Data Collection tools (MDC tools).

The objective of this research is to identify and evaluate existing mobile data collection tools (apps and platforms) for registration in outpatient nutritional programs that meet MSF OCA objectives,

standards and needs. As MDC tools are also being used in other medical disciplines, such as in outpatient maternal health and HIV programs also these tools are taken into account as these can, after minor adaptations, potentially meet requirements of MSF.

The evaluation of hardware is not a part of this scoping exercise, as it is a requirement for any application. The app or platform should function on low-cost hardware, using minimal power and offer sound connection possibilities to import and export data.

This research project was granted funding in August 2017 by the Sapling Nursery Fund. In October 2017, the project manager was contracted.

1.2. Technical framework of electronic registration

Figure 1 shows the flow of work and data when a patient is registered electronically in an ATFC. The data, collected on mobile phones or tablets, must be collected, shared or synchronised in the periphery assuming that there will be no internet connectivity. After data collection in the periphery data is exported to and aggregated on a desktop at the project base, where it can be screened and corrected if needed. The data sent from a user station to a desktop needs to be fed back for further data collection when a patient returns to the ATFC (such as new data on weight, oedema, distribution of RUTF and eventually the discharge data of the patient). After approval, the data is exported to the MSF OCA HIS and to DHIS2 . These systems deliver a report.

Figure 1: Electronic data flow ATFC
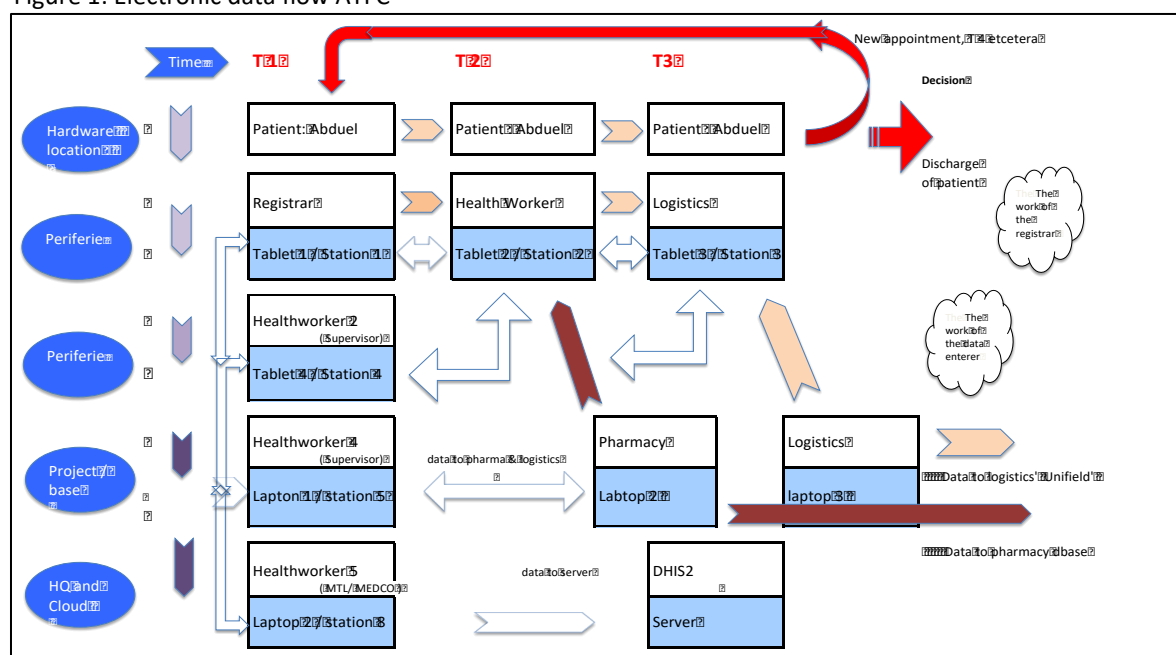
The patient is the data holder and the registration officer (station 1) registers the first set of data: name, family, address and his siblings, nutritional and some medical data at admission. During the next step (station 2) the patient is consulted by a health worker, weight, height and Mid Upper Arm Circumference (MUAC), and oedema is measured and at the following station is medical consultation where some data will be captured like malaria, TB and vaccination status. At the following step (station 3) the patient receives medicines and ready-to-use therapeutic food (RUTF). A new appointment is made, data is synchronised and the cycle repeats itself until the moment the patient is discharged from the program. Some data will be recorded during the enrolment in the program,

such as presence, and upon discharge such weight and date of discharge. When using paper and pen the data described are usually entered in the registration book (and from patient cards in the registration book), from where a data enterer will copy data in an excel sheet. The aim is that the new electronic recording system replaces the paper registration book and replaces the central data enterer.

1.3. Concepts

These data flows are not easy to explain using current terminology. Therefore, this section will introduce a new term for the method of collecting data, explain the difference between apps and platforms, and clarify the concept of Electronic Medical Record (EMR) using definitions developed by the WHO.

1.3.1 Application and platform

- App: an application is a digital tool built for a specific use or purpose. For example the app Buendia that was specifically built by MSF OCA for in- and outpatient nutrition programs. Although the software can be adapted for use in other programs (eg Ebola) the software will remain specific for a certain use.
- Platform: a platform is an electronic structure that allows multiple digital tools (apps) to be built within the same technical framework. The technical framework will be updated regularly and the apps evolve automatically with that update. Several companies have developed data frameworks that offer the possibility to build an app to collect data. These data collection tools can be used on mobile phones, tablets, and desktop computers.

1.3.2 Electronic medical record (EMR) or a registration system

According to the definitions for digital solutions[1] as developed by the WHO, digital tools for registration in the ATFC are in category 2: "digital health interventions" for "health care providers". The following sub-categories apply: client registration (2.1) and client records (2.2), longitudinal tracking of patients (2.2.1) and routine health indicator collection and management (2.2.4).

Longitudinal tracking of patients has different forms. It can be extended, for example where a bedside EMR needs instant data entry to inform patient management, or it can be simple, where data is only entered at patient entry and exit. The latter is the current practice in the registration book of the ATFC's. An EMR system for patient management (including diagnostics, treatment and follow-up on daily basis) should have access to a large quantity of retrospective data, should include a system for data entry by several health providers, and should enable patient management to see all data by providing instant synchronisation and back up of data.

For the eATFC, longitudinal tracking of some data is important to support a good quality of care, such as weight change, presence and absence on appointments to identify defaulters, RUTF distribution. Synchronisation of this data between multiple mobile devices and users is an asset, enabling multiple registration points.

A system for capturing data that are required in an ATFC registration book is different from an electronic medical file (EMR) where all (medical activities) are entered continuously and the patient

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[1] WHO 2018; Classification of Digital Health Interventions v1.0; a shared language to describe the uses of digital technology for health.

can be monitored over time on a daily basis or instantly (bedside like Buendia); this is not our scope.

Electronic registration in an ATFC can be seen as a light form of EMR as some data are tracked over time, but it is not comparable with a full bedside EMR. Therefore we call it "light-EMR", as it still tracks some data over time.
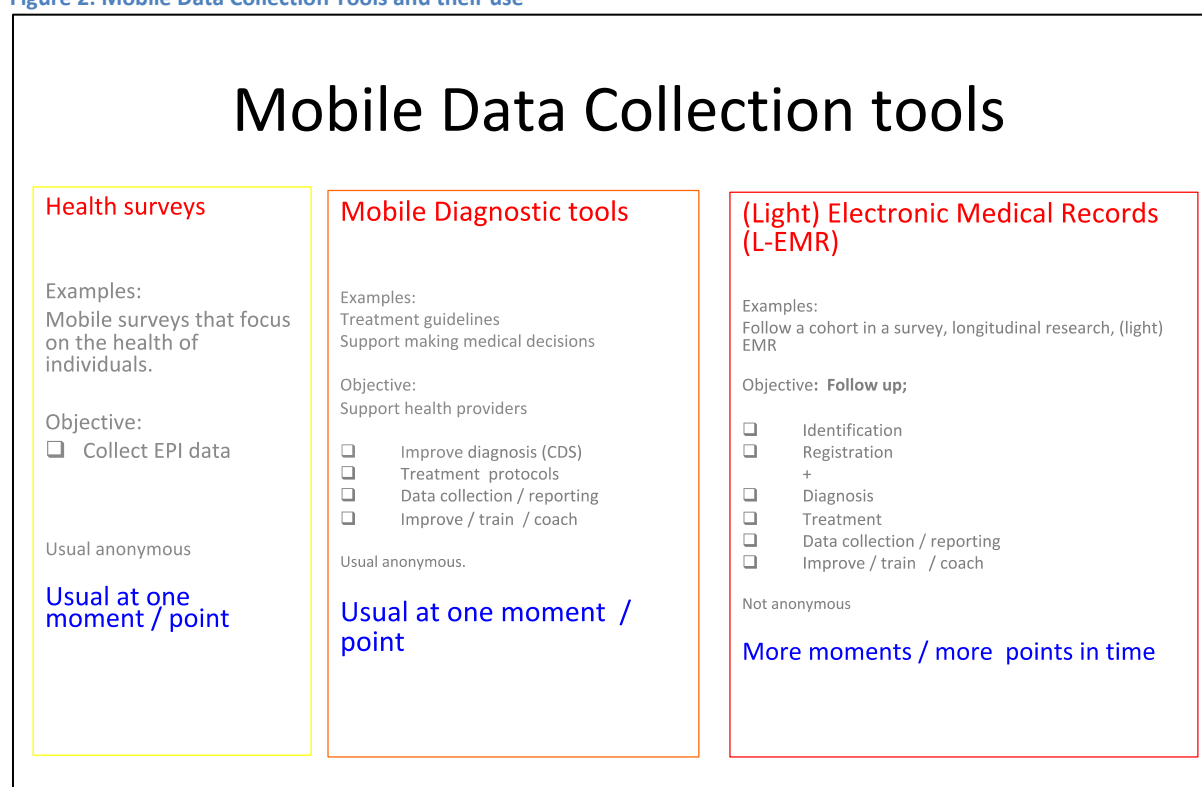Preferably it should enable several users (at different stations) to enter data, requiring only light local synchronisation of data with two or three registrars, and only full synchronisation with the main database when back at the base.

1.3.3 Mobile data collection (MDC)

Using an app on a smartphone or tablet to collect data is called mobile data collection (MDC). MDC tools or apps can run on mobile devices (tablet or smartphone) and desktop computers. An intranet or internet connection (e.g. Near Field Communication or Wi-Fi) or an individual patient data carrier [2] is needed for the communication between mobile devices and/or a central functioning computer.

Figure 2 shows an overview of the purposes for which MDC tools can be used. These purposes vary widely, from surveys to longitudinal follow-up of patients. The MDC tools and/or platforms for ATFC registration purposes need to support client registration, longitudinal tracking of patients, and routine health data collection and reporting (WHO data classifications 2.1, 2.2.1, and 2.2.4).

Figure 2: Mobile Data Collection Tools and their use

Mobile Data Collection tools

Health surveys

Examples:
Mobile surveys that focus on the health of individuals.

Objective:
❑   Collect EPI data

Usual anonymous

Usual at one moment / point

Mobile Diagnostic tools

Examples:
Treatment guidelines
Support making medical decisions

Objective:
Support health providers

❑   Improve diagnosis (CDS)
❑   Treatment protocols
❑   Data collection / reporting
❑   Improve / train / coach

Usual anonymous.

Usual at one moment / point

(Light) Electronic Medical Records (L-EMR)

Examples:
Follow a cohort in a survey, longitudinal research, (light) EMR

Objective: **Follow up;**

❑   Identification
❑   Registration
          +
❑   Diagnosis
❑   Treatment
❑   Data collection / reporting
❑   Improve / train   / coach

Not anonymous

More moments / more points in time

However, most MDC tools are built to collect data at a single point in time and do not offer longitudinal tracking. These survey-oriented solutions do not help health workers in their decision-making process and patient management. E.g. The Manson unit started using a digital tool for

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[2] An individual patient data carrier in our workflow could be a NFC tag. On a NFC tag or wrist carrier data can be stored, read and restored.

epidemiological surveys (Dharma and Kobo platform). Survey tools can be reconfigured to support longitudinal tracking of individuals but are not specifically build for this purpose, which might give problems when scaling up.

Another category of MDC tools (2.3) offers decision support to health care providers. When patient data are entered, the device gives guidance on patient management; patient data are not used to monitor the health of an individual patient. MSF Switzerland implemented a successful mobile health application, running on the platform Mango Logic, that supports health-workers with the diagnosis and clinical decisions. This category is outside the scope of this research because the data is not used to monitor individual patients over time.

A small number of existing MDC tools included WHO categories 2.1 and 2.2 can track patients over time which is required in electronic registration in and ATFC. They offer the features to track, amend and follow-up case or patient data over time.

2. Methods

The scoping research is divided into four phases:

1. Define requirements and functionalities (minimum requirements, optional requirements useful for program management and requirements for a full electronic medical record system) and rate these requirements according to relevance and importance.
2. Explore the market for existing applications and MDC tools. Explore the use of MDC tools by other NGO's.
3. Evaluate the selected apps and platforms with MDC tools against the needed requirements, expected functionalities; explore user experience and management considerations.
4. Propose to deploy an application or MDC tools and make a recommendation for management, based on the evaluation and user experiences.

Interviews were held with MSF staff (requirements) , MDC tool providers (technical requirements and cost structure), and users (experience). Software was tested physically when possible.

2.1 Define data requirements and functionalities

A list of requirements and functionalities was derived from interviews with (medical) staff from the Emergency and Public Health department and the ICT department. Requirements and functionalities were also derived from the current workflows in TFC's, from the previous Buendia electronic patient file project, and from the scoping research of data platforms for surveys (Manson unit).

The requirements for automatic configuration and data transfer to the Health Information System (HIS) was based on the technical functional design of the HIS and DHS2. A complete list of requirements and functionalities was made and rated by the scoping team according to the importance and relevance.

2.2 Explore the market for MDC tools

The market for apps and mobile platform was investigated by searching internet and congresses, interviewing MSF innovation teams, interview with NGO's active in nutrition and through suggestions

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of interviewed users of platforms. The ICT department and the Manson Unit of OCA suggested also possible applications and platforms for patient registration.

2.3 Evaluation of MDC tools

The selected apps and MDC tools were evaluated against the developed framework of data and functional requirements. This resulted in scores that represented the performance of a certain app/platform in a certain category.

Existing software was tested using demos of MDC applications or a we set-up a demo to test the capacities to register and follow patients in an outpatient therapeutic feeding centre. An IT system analyst supported us in this process.

Other NGO's were interviewed to integrate their user experiences in the evaluation of the MDC tools. Within MSF, the following sections shared their experiences and gave their feedback on the use of MDC tools: MSF Brussels (OCB), MSF Barcelona (OCBA), MSF Geneva (OCG), and the MSF Amsterdam (OCA) Manson Unit. Outside MSF, we interviewed the following NGO's: Action Contre Le Faim (ACF), International Committee Red Cross (ICRC), International Medical Corps (IMC), Open Development LCC, Oxfam GB, NOORA Health, Save the Children Fund UK (SCF), Terre des Hommes (TdH), UNICEF, World Heart Federation, and World Vision International (WVI). The ICT department of OCA supported this report and helped searching for possible applications and platforms for patient registration. Interview topics included the reasons for choosing certain MDC software, experience with using in a program, their plans, and challenges.

Several issues raised by MSF management were explored, e.g. necessary investments, running costs, provider service, and compliance with personal data protection regulations.

3. Development of data requirements and functionalities

3.1 Interviews

In November 2017, approximately twenty open guided interviews were done with medical staff working in the Emergency and Public Health Department and staff returning from the field. Most interviewees recognised the dire need to innovate and improve ways of collecting and registering data. Office staff reported being amazed by the high workload to obtain accurate and reliable data. Members of the E desk reported that during the Ethiopian nutrition crisis in (2017) the data collection and registration of malnourished patients created over 6.000 paper patient records in six months. Instant monitoring of the numbers admitted was required in this emergency situation, but not always timely and accurate. Developing overviews also proved to be a monstrous task; after nine months, there was still no complete and correct registration of all patients.

The interviewees had many different expectations of the required functionalities, due to their different tasks and disciplines. Field staff reported a good application to collect rough data of boat refugees. However, this is not a registration tool, merely a tool to collect data. Many interviewees expressed the wish for electronic medical records (EMR), which offer functionalities beyond a patient registration book. While this scoping exercise keeps in mind the required data to register patients (registration book and MSF eATFC data collection requirements), it looks at the feasibility of light EMR instead of full.

3.2 Data Requirements

The research team developed a list of data to enter in an app/process by a MDC, and a list of functionalities. During the scoping process, new information was retrieved from existing and previous apps, interviews, and software engineers, which yielded important functionalities for the evaluation of apps /platforms and MDC's.
All collected requirements and functionalities where gathered in a spreadsheet (data requirements separated from the functional requirements).
The data requirements have been rated on relevance and importance.

Minimum requirements are:
- Information normally collected in the registration book
- Information required in the HIS program
- Information needed to monitor progress of certain activities, mentioned in the MSF OCA strategic plan 2015-2019 (e.g. vaccination status)
- Information required by UNICEF

If a minimum requirement is not present and can't be added, the app/platform is not suited for OCA.

Optimal requirements are:
- Information on the wish list of future users and stakeholders
- Information that could be useful for other departments, e.g. the possibility to register RUTF distribution

Electronic Medical Record
- Data used for individual patient monitoring and management, but not necessarily used in the registration book

The rating was based on minimum requirements (1), optimal requirements (0,66) and those required in an electronic medical record (0,33).

In total 51 data requirements were collected and allocated into 4 categories:
- Patient Identification, 13 items (9 minimum, 4 optimal)
- Anthropometry (Admission Data), 11 items (6 optimal and 5 EMR)
- Medical Requirements, 20 items (9 minimum and 11 EMR)
- Program requirements, 6 items (3 minimum, 1 optimal and 2 extended)

Table 1: Example of requirements and the rating of category data for patient identification

Category	Description of requirements	Rating		
Patient Identification		1 minimum	2 optimal	3 EMR
	MSF ID health card	X		
	ID number / health number	X		
	Family name	X		
	First name	X		
	Age (months)	X		
	Gender	X		
	Name caretaker	X		
	Village	X		
	Address	X		
	Telephone number		X	
	Finger print / IRIS scan (embed grading)		X	
	Photo patient		X	
	Photo care taker		X	

In the above category, most requirements are minimal; telephone number, patient fingerprints, patient photo and caretaker photo are optimal requirements.

3.3 Functionalities

The interviews, Buendia app, and input from other scoping research contributed to a long list of required and preferred functionalities. The total list exceeded 100 functionalities. Similar to the data requirements, the functionalities were divided in categories:

1. The performance of the platform
2. The access and security of the platform
3. The possibility to scale and modify the platform
4. The possibilities to analyse and make overviews
5. The registration and use options
6. The possibilities to integrate and be compatible with other platforms or apps
7. The acceptance and user-friendliness
8. The expected support and future proof of the platform or app
9. The safety, back-up and synching of data
10. The future cost of using the app or platform in the field

As illustrated below, an MDC tool that has been deployed in the field and is able to register and follow-up the data of over 1.000 patients receives a rating of 1. MDC tools that are tested with 20.000 patients receive 2 more points. (Initially, a test on 50.000 patients was planned, but this proved unrealistic.)

Table 2: Example of functionalities

Number	Category	electronic register book in ATFC = Description of functionalities	Final Rating
1	Performance app	Capable of registering more than 1.000 patients	1
		Tested with 1.000 patients	1
		Tested with 20.000 patients	2
		Deployed and fully operational in the field (reference/recommended)	2
		Providing real-time aggregated data of number of admissions	2

The example below lists the functionalities that indicate how a tool/platform might perform and be sustained over time.

Table 3: Example of future-proof rating

Number	Category	electronic register book in ATFC = Description of functionalities	Final Rating
8	Future Proof	Non-vendor locking	2
		Owner of platform does not have ownership or access to the data	2
		Automatic updates by company that built the app	2
		Appropriate documentation developed to support trainings	2
		Online training to set up and adapt the platform	2

3.4 Other considerations

A digital tool to register patients in an ATFC electronically has other important features besides data and functional specifications. The information on data requirements and functionalities came

predominantly from the app/platform providers; it is important how this is functioning in practice. We therefore have included the experiences of other users.

In addition, decision makers need additional information important for the management MSF; Therefore some key components were explored as. The costs, the service of the provider, and data protection regulations were examined.

4. Evaluation of existing software

Existing MDC platforms and apps were captured through MSF contacts, existing benchmark exercises, interviews with other NGO's known to be active in (e-)health (snowball effect) and a search on internet. OCBA and the Manson Unit reviewed mobile data collection platforms. The review of the Manson unit focused on the selection of electronic survey platforms that can be used in field surveys, resulting in the selection of the Dharma and Kobo platforms. OCBA focused on an easy-to-use MDC tool; case management was not a priority. The NGO's CartONG and Kopernik also performed an interesting benchmarking of MDC tools. Through these benchmarking exercises 29 MDC tools were identified; other searches added 2 applications to the list of potential application and platforms resulting in a total of 31 potential platforms/apps to be evaluated.

The criteria for extracting a shortlist of MDC tools to be evaluated in detail were: track record of MDC with medical NGO's, focus on longitudinal case management, and a functional mobile application (See annex 7 for a full list and their compliance with these criteria).

As a result, the following six MDC tools were selected for evaluation:
4.1   Survey CTO, a MDC platform
4.2   Commcare by Dimagi Inc., a MDC platform
4.3   Dharma by Dharma Platform Inc., a MDC platform
4.4   Mango Logic developed by Thing Prima GmbH, a MDC platform
4.5   Buendia, an app developed by MSF Amsterdam
4.6   Easynut, an app developed by MSF Belgium

4.1 Description apps and platforms

4.1.1 Survey CTO platform

Survey CTO is an open-source Mobile Data Collection platform that helps the user capture, transport, and process data collected during personal interviews (Computer Assisted Personal Interviews, or CAPI). Survey CTO is based on Open Data Kit (ODK). The MDC tools of Survey CTO are deployed in 130 countries. Survey CTO has added features that can help the user manage individual cases and/or patients. For this functionality, an enterprise license needs to be signed. Datasets can be made in Excel and in Google Sheet. The developing language is Javascript. Dobility Inc. is the company behind Survey CTO.

4.1.2 Commcare platform by Dimagi Inc.

In Commcare, users can build forms to collect and register data. Commcare has a large user base in Africa and Asia. Forms that are built on this platform are used in over 150 countries. Apps or forms built on the Commcare platform have proven to work well in low-resource settings. Commcare has its own service and support organisation operational in East, South and West Africa. Commcare is based on Open Data Kit (ODK) and Commcare designs smart interfaces to help users collect data. It uses Xforms and the JavaScript language. Dimagi Inc. is the company behind Commcare.

4.1.3 Dharma Platform by Dharma Inc.

Dharma Platform can manage different data collection projects within one platform. It provides an application with collection, management, analysis, and visualization features, which can be used real-time in health, logistic, and research sectors. Several NGO's working in crises and development context use the Dharma platform to collect data. Dharma is committed to empower organizations to solve complex data challenges in difficult environments. MSF is using the Dharma platform for surveys and other data that are usually are collected with tally sheets. Dharma enables non-programmers to configure, maintain and validate data challenges.

4.1.4 Mango Logic platform developed by Things Prime GmbH

Mangologic is a platform that facilitates the development of mobile decision-support and data collection systems. Things Prime GmbH, a Swiss private limited company, has developed the software. D tree International, the service provider, leverages technology to build digital solutions that supports other NGO's to strengthen their health systems. D three deployed the application of Mangologic in 9 countries in Sub-Saharan Africa and in India, Bangladesh and Myanmar.

Mangologic is also used in MSF OCG's eCARE project, Electronic algorithms to support diagnoses and treatment in Integrated Management of Childhood Illnesses (IMCI) programs; it is being rolled out in several African countries. MSF OCG has also used Mangologic successfully in a vaccination campaign in Central African Republic. Mango-logic MDC tools are deployed in Maternal Health programs in Tanzania and in Zanzibar for follow-up of the pregnant women.

Mangologic permits non-programmers to configure, maintain and validate even complex decision logic. The registration and longitudinal tracking of clients is a standard functionality of this software.

4.1.5 Buendia app by MSF OCA

The Ebola outbreak in 2016 highlighted the need for paperless, electronic patient files. The app Buendia was designed to manage patients admitted to TFC's and to manage the electronic medical records more efficiently. The app was tested in the field, but further development was halted due to difficulties synchronising the comprehensive data of multiple simultaneous users. MSF OCA has prioritised the development of a health information system based on DHIS2. Buendia was built on Open MRS software using the JavaScript language. Although the decision was taken to stop any further development we evaluated the application.

4.1.6 Easynut app by MSF Belgium

The application developed by MSF Belgium, Easynut, is an example of how the data requirements of a Therapeutic Feeding Unit have been translated into an application to collect patient data

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electronically. The application is a tool that helps register, record and follow up patients over time. All the standard and non-standard data requirements are integrated. Currently MSF Belgium manages a cohort of Nutritional Patients over the course of 3 years. The disadvantage of this app is that it does not work in areas without connectivity.

The goal of Easynut was to get away from more heavy and complex platforms (OpenMRS, OpenEMR) and to offer something more limited and simpler to configure. The app has been made in Python 2.7 using the Django framework.

Easynut has been deployed in the ITFC/health centre of Fori (Maiduguri, Nigeria) with 25 users and 5.000 patients. It is not an MDC tool, as it cannot function without a Wi-Fi or Intranet connection. Although the software is operational in the field and works as a proof of concept, it has been decided to halt the further development of the app. MSF Belgium has prioritised the development of DHIS2.

4.1.7 Summary description

The following table summarises the design structure of the tools:

Table 4: Data analysis and overview

MDC platform/app	Survey CTO	Comm care	Dharma	Mangologic	Easynut	Buendia
Type of framework	ODK	ODK	Own framework	Own framework	Django	JDBC 4
Form types	XLS, Google Sheets	Xforms	Own form	Own form	HTML form	Xforms
Development language	Javascript	Javascript	Python & Java script	Java	Python	Javascript
Client Android	YES	YES	YES	YES	YES	YES
Client IOS	NO	NO	YES	NO	NO	NO
Client Windows	YES	YES	YES	YES	YES	YES
Data base server	Amazon web Services	MySQL	Google	Google Firebase	MySQL	MySQL
Database type	MySQL/postgreSQL	MySQL	DBMS	MySQL/Google Firebase	MySQL	SQlite
Hosting	Linux	Linux	Linux	Linux	Linux	Linux
Remarks			Google specialist in AI	Google specialist in AI	Stopped development	Stopped development

Survey CTO and Commcare were founded on the open source Open Data Tool Kit. Both platforms use XLS / X forms to start an application. Dharma and Mangologic made stand-alone digital tools where you directly compose or write your application on the platform. Easynut and Buendia were developed by application developers. Both Dharma and Mangologic make use of Google technology. Google focuses its developments in the growing field of Artificial Intelligence (AI). By using Google as database server, Dharma and Mangologic can closely follow these developments, integrate smarter algorithms, and hence develop 'smarter' MDC tools.

4.2 Benchmarking the apps and platforms

To support the registration and case management of nutritional patients in outpatient therapeutic feeding centres we have defined 51 data requirements. These 51 data requirements were divided in 4 categories:
1. Patient Identification; standard and extended
2. Anthropometry; standard, extra and extended
3. Medical; extra and extended
4. Program; standard, extra and extended

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4.2.1 Patient Identification

Table 5: Standard patient identification

Patient ID		Max rate	Survey CTO	Comm care	Dharma	Mangologic	Easynut	Buendia
standard	MSF ID health card	1	1	1	1	1	1	1
	Patient number	1	1	1	1	1	1	1
	Family name patient	1	1	1	1	1	1	1
	First name patient	1	1	1	1	1	1	1
	Age patient (months)	1	1	1	1	1	1	1
	Gender	1	1	1	1	1	1	1
	Name caretaker (father, mother)	1	1	1	1	1	1	1
	Village	1	1	1	1	1	1	1
	Address	1	1	1	1	1	1	1
	Total	9	9	9	9	9	9	9

All evaluated MDC tools are able to register the standard patient identification data.

Table 6: Extended patient identification

Patient ID extended		Max rate	Survey CTO	Commcare	Dharma	Mangologic	Easynut	Buendia
	Telephone number	1	1	1	1	1	1	1
	Biometric ID (FP, iris)	0.33	0	0	0.16	0.33	0	0
	Photo patient	0.33	0.33	0.33	0.33	0.2	0	0
	Photo caretaker	0.33	0.33	0.33	0.33	0.2	0	0
	Total	1.99	1.66	1.66	1.82	1.73	1	1

Not all evaluated MDC tools are able to collect extended identification data (fingerprints and photos). With Survey CTO Collect, Commcare, Dharma, and Mangologic, it is possible to add the photo of a patient and of their caretaker(s). Mangologic also offers the feature to add fingerprints to the identification process. Dharma does not offer this feature yet, but is investigating the option with its engineers.

4.2.2 Anthropometry

Table 7: Standard anthropometry

Anthropometry standard		Max rate	Survey CTO	Commcare	Dharma	Mangologic	Easynut	Buendia
	Weight	1	1	1	1	1	1	1
	Height / Length	1	1	1	1	1	1	1
	Weight/Weight Z-score (manual)	1	1	1	1	1	1	1
	MUAC	1	1	1	1	1	1	1
	Oedema	1	1	1	1	1	1	1
	Discharge weight	1	1	1	1	1	1	1
	Total	6	6	6	6	6	6	6

All evaluated MDC tools are able to register and manage a patient's standard anthropometry over time.

Table 8: Non-standard anthropometry

Anthropometry		Max rate	Survey CTO	Comm care	Dharma	Mangologic	Easynut	Buendia
Extra	Admission criteria	1	1	1	1	1	1	1
Extended	Weight/Weight Z-score (automatic)	1	1	1	1	1	1	1
	Oedema (0, 1+, 2+, 3+)	1	1	1	1	1	1	1
	Discharge MUAC	1	1	1	1	1	1	1
	Discharge Length/Height	1	1	1	1	1	1	1
	Total	6	6	6	6	6	6	6

All evaluated MDC tools are able to register and manage the patient's non-standard anthropometry over time.

4.2.3 Medical

Table 9: Standard medical treatment

Medical treatment standard		Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easy nut	Buendia
Extra	Malaria test	1	1	1	1	1	1	1
	Outcome malaria test	1	1	1	1	1	1	1
	TB test	1	1	1	1	1	1	1
	TB status	1	1	1	1	1	1	1
	HIV test	1	1	1	1	1	1	1
	HIV status	1	1	1	1	1	1	1
	Vaccinations given (list in HIS)	0.66	0.66	0.66	0.66	0.66	0.66	0.66
	Vaccination status on exit (complete, partial, none)	1	1	1	1	1	1	1
	Vaccinated for measles	1	1	1	1	1	1	1
	Total	8.66	8.66	8.66	8.66	8.66	8.66	8.66

In an outpatient nutritional feeding centre, the current MSF OCA strategy is to test patients for malaria, TB, and HIV. The patient's vaccination status upon admission and discharge are also assessed. All evaluated MDC tools are able to monitor these results.

Table 10: Medical state at admission

Medical state at admission		Max rate	Survey CTO	Comm care	Dharma	Mangologic	Easynut	Buendia
Extended	Temperature	0.66	0.66	0.66	0.66	0.66	0.66	0.66
	Malaria	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Previously in OPD/IPD	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Breast feeding status	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Consciousness	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Pulse & heart rate	0.66	0.66	0.66	0.66	0.66	0.66	0.66
	Respiratory rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Medication	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	General condition	0.66	0.66	0.66	0.66	0.66	0.66	0.66
	Appetite test	0.33	0.33	0.33	0.33	0.33	0.33	0.33
	Vital signs	0.66	0.66	0.66	0.66	0.66	0.66	0.66
	Total	4.43	4.43	4.43	4.43	4.43	4.43	4.43

The above-mentioned extended medical conditions are usually not captured in the reporting of an outpatient nutritional facility. However, when patients require daily care, these conditions are monitored electronically, i.e. an EMR. All evaluated MDC tools are able to record the data.

4.2.4 Program data

Table 11: Monitor program functioning

Program functioning		Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easy nut	Buendia
standard	Date of admission	1	1	1	1	1	1	1
	Referral from	1	1	1	1	1	1	1
	Date of exit	1	1	1	1	1	1	1
	Type of exit (cured, defaulter, death, etc.)	1	1	1	1	1	1	1
	Type of admission (new, relapse, etc.)	1	1	1	1	1	1	1
	Extra information, e.g. receiving food aid	1	1	1	1	1	1	1
	Number of RUTF given	0.66	0.66	0.66	0.66	0.66	0.66	0.66
		6.66	6.66	6.66	6.66	6.66	6.66	6.66

All necessary data to manage the nutritional program is integrated or can be integrated into the evaluated MDC tools. In the Easynut application, the distribution of RUTF is recorded and the data are exported/shared with the logistics department to support stock management. In all other MDC tools, this can potentially be incorporated.

4.2.5 Conclusion Data Requirements

All evaluated MDC tools have integrated or can integrate the data requirements of an outpatient nutritional centre.

Table 12: Summary data requirements

		Survey CTO	Comm care	Dharma	Mangologic	Easynut	Buendia
Patient Identification	Standard	9	9	9	9	9	9
Patient Identification	Extended	1.7	1.7	1.8	1.7	1	1
Anthropometry	Standard	6	6	6	6	6	6
Anthropometry	Extended	4.3	4.3	4.3	4.3	4.3	4.3
Medical	Extra	8.7	8.7	8.7	8.7	8.7	8.7
Medical	Extended	4.4	4.4	4.4	4.4	4.4	4.4
Program data	all	0.7	0.7	0.7	0.7	0.7	0.7

As the categories of data requirements are not weighted, the rating of the different aspects cannot be summed up to construct one single total score. The MDC tools have score similar ratings, with the exception of added patient identification features. Mangologic has experience with adding biometrics to patient identification processes. They also have experience in circumventing biometrics by giving a patient an electronic token/card with their data.

4.3 Functionalities

The Easynut and Buendia apps do not function properly without an internet connection. These apps are therefore not suited for an outpatient nutritional centre. Both applications have been evaluated in this research as they have deployed user-friendly features that could be useful in a pilot project. In this chapter, the functionalities of all six data collection tools will be evaluated.

The functionalities were categorised into nine subgroups. In the following paragraphs, the results of benchmarking MDC tools are presented.

4.3.1 Performances of the MDC tools

Table 13: Technical performance

Technical performance	Max rate	Survey CTO	Comm care	Dharma	Mangolo gic	Easynut	Buendia
Capable of processing > 1.000 complete records	1	1	1	1	1	1	
Tested with 1.000 patients/records	1	1	1	1	1	1	
Tested with 20.000 patients/records	2	2	2	2	2	1	
Tested and proved to be accurate by client	1	1	1	1	1	1	
Real-time/timely, providing total number admissions	2	1,5	1.5	2	2	1	
Total	7	6.5	6.5	7	7	5	

The MDC tools Survey CTO, Dharma, Mangologic all are capable to collect more then 1000 records. The scores of Commcare were slighty lower, Easynut was rated as medium, and Buendia was not tested. Survey CTO, Commcare, Dharma and Mangologic all function in offline /off-grid contexts, while Easynut and Buendia require instant online connections.

4.3.2 Access and security

Table 14: Technical management

Technical management	Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easynut	Buendia
User log on required (automatic log off)	1	1	1	1	1	1	1
MDC tools PIN-protected on mobile and desktop	1	1	1	1	1	1	1
Secure password for Wi-Fi, Open MRS, or DHIS2	1	1	1	1	1	1	1
Role-based, user rights can be limited	2	2	1.5	2	2	2	2
Data sharing and export /import encryption	2	2	2	2	2	2	2
Software and data can be hosted on own server	3	2	2	2	2	1	1
Total	10	9	8.5	9	9	8	8

Survey CTO, Commcare, Dharma, and Mangologic work well with multiple users user logo on, security and roles can be all well organized. Data can be shared and export and imports can be encrypted. They also all offer the possibility to host software and data on a client server but so far, only International Committee of the Red Cross (ICRC) accomplished to host the software and the collected data on its own servers.

All four evaluated MDC platforms offer the possibility of encrypted data sharing (the 2 apps Buendia and Easynut excluded). Dharma and Mangologic use various ways to collect data, based on the different roles/users and hierarchies of staff.

The data structure of Survey CTO and Commcare has not been designed for local or remote data sharing between stations. Data needs to be updated and synchronised via a central server before data can be added by other users or stations. Therefore, Survey CTO and Commcare can only function optimally when the workflow in the ATFC is adapted to enable the use of one tablet or station for data entry. Dharma and Mangologic do have the ability to share data between users/stations in an off-line context (See the illustrated workflow of our ATFC in Figure 1.) The sharing of data can be enabled via NFC communication or a data carrier.

4.3.3 Flexible, scalable and easy to modify

Table 15: Simplicity programming

Simplicity programming	Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easynut	Buendia
Flexible, scalable, easy to maintain	2	2	1	2	2	1	0
MDC solution can be amended by capital and HQ	1	1	1	1	1	1	0
Can modify all data entry variables on user desktop	2	2	1	2	2	2	2
Can integrate with e-ITFC app or other apps	2	2	1	2	2	0	2
Can export data to EMR	2	2	1	2	2	2	2
Can upload from registration book/patient cards	2	2	1	2	2	2	2
Can delete/edit offline and real-time by supervisor	2	1	1	2	2	2	1
Total	13	12	7	13	13	10	9

Dharma and Mangologic offer the best option when it comes to amending and scaling the application. A new information line in the data entering form doesn't have an impact on the data exportation to another data tool (e.g. DHIS2). Commcare users expressed difficulties in amending

tools and exporting data. Survey CTO, Dharma and Mangologic have good functionalities to export data. Dharma and Mangologic are the most flexible, scalable and easiest to maintain.

4.3.4 Capacity to make analyses and overviews

Table 16: Data analysis and overview

Data analysis and overview	Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easynut	Buendia
Provides statistics relating to activity data enterers	2	2	2	2	2	2	1
Automatically calculates average length of stay (ALS)	1	1	1	1	1	1	1
Automatically calculates average weight gain (AWG)	1	1	1	1	1	1	1
Gives number admitted /day/week/month	1	1	1	1	1	1	1
Gives number exited by period and mode	1	1	1	1	1	1	1
Automatically calculates W/H z-score and BMI	1	1	0	1	1	1	1
Gives overview absentees	2	1	1	2	2	1	1
Shows nutritional progress per patient	2	1	1	2	2	1	1
Frequent use of visuals/dynamic interface	2	2	1	2	2	2	2
Alarm when observations are outside normal range	2	2	1	2	2	2	2
Gives overview/summary of data	3	2	1	3	3	2	3
Total	18	15	11	18	18	15	15

Dharma and Mangologic offer a superior functionality to make instant summaries or overviews of collected data. Survey CTO and Commcare are robust tools to enter data, but fail to make these quick and simple analyses or overviews before the file has been transmitted or uploaded to the server.

4.3.5 Capacity to make registration book, patient card, and use of data points

Table 17: Practical features

Interface	Max rate	Survey CTO	Comm care	Dharma	Mango Logic	Easynut	Buendia
Can generate print of register book	1	1	1	1	1	1	1
App can generate patient number and card	1	1	1	1	1	1	1
NFC bootstrapping mechanisms for data transfer over Bluetooth or Wi-FI Direct	2	2	2	2	2	0	0
Multiple users can use app offline and share via NFC	3	2	2	3	3	0	0
Persistent fields (pre-filled form) possible	2	2	2	2	2	2	2
Free text responses possible	1	1	1	1	1	1	1
Multi-lingual : English, French, Swahili and Arabic	1	1	1	1	1	1	0
Use cursor position right or left (European/Arabic)	3	3	3	3	3	0	1
Can search on fingerprint	2	0	0	1	2	0	0
Total	16	13	13	15	16	6	6

The MDC applications were evaluated on practical and helpful features in a remote setting. One example is that users indicated the importance of being able to print out a patient's complete file. It is also an advantage when data can be shared in an offline mode.

All MDC tools offer the possibilities to print patient files, and search for patients with various tools and wildcards. All tools are able to design custom user roles with their own permissions to access forms, datasets, and functions.

Dharma and Mangologic are able to work in an offline mode and update data using near field communication (NFC), which was tested by uploading a complete form (our 51 questions) of approximately 1,5 Kbits via NFC. Please note that data size increases significantly when a patient fingerprint or photo is added. If the form becomes too large or the distance between users/stations exceeds 10 meters, a personal patient data carrier can improve the connection.

Mangologic offers the functionality to search a patient with a fingerprint. Mangologic also has proven experience to connect the digital tool to other digital applications.

4.3.6 Software compatibility and data sharing

Table 18: Data sharing and compatibility

Data sharing and compatibility	Max rate	Survey CTO	Comm care	Dharma	Mango Logic	Easynut	Buendia
Runs on tablets and smart phones with Android V6 or higher	2	2	2	2	2	2	2
Runs on tablets and smart phones with iOS V10 or higher	1	0	0	1	0	0	0
Export data via CSV to a HMIS system like OpenMRS/Open EMR, HIS, and DHIS2	2	2	2	2	2	2	2
Automatic upload to server when device connects to Wi-Fi/3G	2	2	2	2	2	2	2
App can be easily set up in the field (download)	2	2	2	2	2	1	1
Standard format data exports Excel, PDF, XML, CSV	1	1	1	1	1	1	1
Automatic updates	2	2	2	2	2	0	0
Sharing or sync of data via NFC (Bluetooth or Wi-FI Direct)	2	1	1	2	2	0	0
Sharing data via NFC chip or carrier	1	0	0	0	1	0	0
Total	14	12	12	14	13	8	8

All MDC tools run on Android, which is the most used operating system in Africa and Asia. The Dharma platform also runs on iOS. All evaluated MDC tools can export the collected data to desktop and, after completing and approval, export the data in csv format to hospital management and information systems and databases, e.g. the MSF HIS system and DHIS2.

Dharma and Mangologic offer proved user-friendly ways to share data between users in the field. For example, if three people work in a remote ATFC, with separate stations and not connectivity, they can still share and update their data via NFC.

Mango Logic advised not to share data via NFC (WiFi-direct or Bluetooth) as it would mean that a health worker would need to walk to an other health worker to share the data collected. Mango Logic advised to use a NFC chip or data carrier, which should be carried and kept by the patients. The NFC will function as a unique identifier and can pass data between stations.

 If a small picture would be stored it would give us direct support in recognizing a patients and his records. Other MDC tools have not advised on this domain. We have inserted an extra line in Table 18 and granted an extra score of 1 point.

Figure 3; An example of a NFC chip or token as unique data carrier.

4.3.7 Acceptance and user-friendliness of MDC tool

Table 19: Reported acceptance and user-friendliness

User-friendliness	Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easynut	Buendia
Accepted and found user-friendly by field staff	1	1	0	1	1	1	1
Accepted by patients and caretakers	1	1	1	1	1	1	1
Intuitive interface for program users	2	1	1	2	2	2	1
Simple visuals can be used	1	1	1	1	1	1	1
Search on patient ID including wild card	1	1	1	1	1	1	1
Saves time in data entry and aggregation	1	1	1	1	1	1	1
Simultaneous multi-user possible	3	2	2	3	3	2	1
Total	10	8	7	10	10	9	7

Users reported that MDC tools are accepted in most countries by patients and their caretakers. In most countries, a health worker seen with a MDC device is taken more seriously than one without. However in other countries MDC are not trusted (e.g. Lebanon). The MDC tools of Survey CTO and Commcare are experienced as less user-friendly than Dharma and Mangologic. Both Dharma and Mangologic can give various summaries of the collected data. Also, data collected in the past can be retrieved. Another advantage of Dharma and Mangologic is the ease to work with multiple users addressing various roles.

4.3.8 Safety, backup and synchronisation ease

Table 20: Safety, backup and synchronization

Safe synchronisation	Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easynut	Buendia
Password-protected backup on USB	1	1	1	1	1	1	1
Automated backup with timer function	2	2	2	2	2	2	2
All data have timestamp of last user	1	1	1	1	1	1	1
Encrypted data traffic between users–server, user-user	2	2	2	2	2	2	2
Data-sharing between users in the field via NFC	2	1	1	2	2	0	0
Synchronisation with field server within 5 minutes	2	2	2	2	2	2	2
Total	10	9	9	10	10	8	8

All evaluated MDC tools offer thorough safety and backup functionalities.

4.3.9 Support, training, and future-proof features

Table 21: Support by provider

Support by provider	Max rate	Survey CTO	Comm care	Dharma	Mango logic	Easynut	Buendia
Can be supported at field level by senior user	1	1	1	1	1	1	1
Minimal on-site technical support	2	1	1	2	2	1	1
Based on standard modern frameworks and techniques	2	2	2	2	2	1	1
Service layered architecture and API's	1	1	1	1	1	0	1
Non vendor lock-in (Apple , Oracle, Commcare)	2	2	1	2	2	2	2
Platform provider does not have access to data	2	2	2	2	2	2	2
Automatic update by platform/app provider	2	2	2	2	2	2	2
Appropriate documentation to support training	3	3	3	3	3	1	1
Training to set up/adapt app available/online	2	2	2	2	2	1	0
Tech support is available from provider	2	2	1.5	2	2	1	1
Total	19	18	16.5	19	19	12	12

The introduction and sustainability of a new and innovative working tool in our outpatient nutritional facilities needs the support of the innovation department, the IT department, nutritional advisors,

medco's and MTL. An MDC tool that is easy to understand, offers plug and play logic and demands minimal onsite technical supports this dynamic.

Mangologic and Dharma are MDC tools that are easy to understand, do not need specific programming knowledge, offer wider functionalities, and hence can be deployed and scaled up more easily. Users and supporting departments are likely to understand easily both applications; hence, reliance on support of the tool provider is limited. Commcare and Survey CTO are more complex platforms and users would need more support from the providers.

All evaluated MDC tools offer in-house training, online documentation and technical support.

4.3.10 Summary performance functionalities

Table 22: Summary performance functionalities

Summary performance functionalities	Survey CTO	Comm care	Dharma	Mango logic	Easynut	Buendia
Technical performance	C	C	A	A	E	
Technical management	A	D	A	A	E	E
Simple programming	C	F	A	A	D	E
Data analysis	C	F	A	A	C	C
Practical features/interface	C	C	B	A	E	E
Data sharing compatibility	C	C	A	B	E	E
User-friendliness	D	E	A	A	C	E
Synchronisation and safety	C	C	A	A	E	E
Support	C	D	A	A	E	E

The total rating of the different functional categories cannot simply be added up as the categories are not weighed. To visualise the differences, the ratings are ranked by assigning a letter (A, B, C, D, E, F); A for the highest rate, B for the next, etcetera. If tools had the same rate, they received the same letter, but a letter was skipped for the next tool, e.g. tool 1 and 2 both received an A and tool 3 received a C. This resulted in a clear picture of the rankings.

The table above highlights that Dharma and Mangologic got the best scores on performance functionalities, followed by Survey CTO. Remarkable is that Commcare, the most widely distributed MDC platform, ranks lower than Dharma, Mangologic and Survey CTO in our evaluation of mobile data tools where data-sharing between users in offline mode is essential. In addition, Commcare is perceived more complex to program. Commcare explained that their design principles, based on the ODK toolkit and their interfaces are not developed with the intention to manage cases in an offline context between various users or stations.

4.4 Evaluation of the Mobile Data Collection tools by their users

During the survey, we interviewed a large number of NGO staff working with electronic registration tools and mainly in the domain of nutrition. All NGO's collaborated and shared their experiences with the MDC they have deployed in the field. We asked questions about performances, functionalities and challenges of the MDC application used. We also asked some participants about their rationale to choosing a certain tool. We learned that very few organisations have changed their MDC provider after a first experience.
Easynut has a small user base and its development has been stopped; Buendia is not operational. Therefore these tools are not investigated further.

4.4.1 Survey CTO

Survey CTO has a very large user base all over the world. The platform is used in 130 countries. Most of its applications are used in academic studies, research, and surveys. Among others, Noora Health and Oxfam GB have deployed Survey CTO in the field, to improve the health outcomes of groups of patients.

Noora Health is an NGO that gives training to relatives of patients in hospitals, so the relatives can provide better care and fewer people have to be readmitted to hospital. Noora Health uses the Survey CTO platform to evaluate the quality of the trainings and to follow the post-discharge health outcomes of the patients. Participants are contacted by telephone at regular intervals and the outcomes are assessed. For example, In India, over 90.000 family members have been trained, resulting in a 25% reduction of readmitted patients.
Noora Health (NGO) is satisfied with the platform for these phone-based surveys but doubts if the platform, as in our case, functions properly when it is used simultaneously by multiple users in an offline context.

Oxfam has implemented MDC tools based on Survey CTO for survey's and assessments in 50 to 60 countries and OXFAM staff like the flexibility of the tool. Oxfam also uses electronic case management tools to monitor, evaluate, account and learn from the direct feedback from the community. These tools have been deployed in Tanzania, Ethiopia, Myanmar and Iraq. Oxfam uses also other MDC tools to collect data.

The vision of the Oxfam team is that MDC tools is in important element for organization growth ''it is faster, the data is more accurate, reliable and of a better quality, the novelty factor, trust and possibilities to faster interact with communities will have the desired effect on our organization''.

Oxfam is deploying MDC tools since 8 years and is steadily scaling up the use, over the years they gathered an enormous experience and knowledge. The Oxfam innovation team works with 8 people for countries that demand support. The innovation department OXFAM did deliberately choose for platforms as opposed to specific apps: "developing an app yourself, in-house, that is an absolute stop as these are not scalable and not sustainable".

4.4.2 Commcare

The Commcare platform has the largest user base in Africa and Asia. Most NGO's we contacted have experience with Commcare, including International Committee of the Red Cross (ICRC), Save the Children, World Vision, Terre des Hommes, and World Heart Foundation. Action Contre la Faim plans to deploy a Commcare application for nutrition in collaboration with World Vision and Terre des Hommes.

Both Terre des Hommes and ICRC expanded the use of Commcare digital tools beyond nutrition and use the platform to support health workers with clinical decisions and reporting. In Burkina Faso, Terre des Hommes supports over 600 health centres that use Commcare as part of the Integrated Management of Childhood Illnesses (IMCI) program, processing 200.000 children per month. This is possibly the largest caseload on which an MDC tool is deployed. In the 600 clinics, 75% of the consultations are supported by a mobile applications but not all consultations as not all staff is qualified to use tablets.
The Ministry of Health (MoH) of Burkina Faso is very positive about the program as it helps to deliver timely reports to the international donors.

Over the past eight years, Terre des Homme have invested up to $1.000.000,- in Mobile Data Collection tools and staff training. On average, every new version costs $100.000,- to develop and update. The first versions were more expensive than their most recent updates.

ICRC has developed an app on the Commcare platform called Almanac and deployed it in Nigeria. ICRC has trained staff that is qualified to modify the application. ICRC is the only organization that stores the collected data on their own servers, enabling them to remain in full control of access to the data.

Several NGO's have reported successful deployment of Commcare applications to improve the care to nutritional patients. However, over the course of this research, it became clear that most organisations had to reduce the implementations due to funding difficulties. Currently only Save the Children and World Vision register malnourished children in an outpatient nutrition program.

Neither World Vision or Save the Children has in-house specialists who are able to manage the data aggregation and flows, and who have experience in adapting the Commcare apps (e.g. data entry fields). Consequently, they are dependent on services and expertise provided by Commcare, which brings additional costs.

The applications developed by Commcare for World Vision and Save the Children do not represent the workflow and use of MSF. We are looking for a tool to replace the register book and the follow-up of patients in an ATFC in a remote setting. The Commcare application for World Vision is designed for data collection by one health worker/station, one patient at a time. The Commcare forms cannot be shared with another user/station in an offline mode.

4.4.3 Dharma Platform

The Dharma platform was developed for survey purposes, but it can also be used to follow up patients. Dharma is currently being used by the OCA Manson unit to collect data in surveys.

In Syria, in the Busra Hospital, the Dharma platform is used to collect and aggregate the statistics of all departments. It does not use Dharma to follow up patients. However, there are plans to pilot Dharma for the follow-up of patients in selected cohort programs.

The International Medical Corps (IMC) intends to use Dharma as a survey tool and as an EMR in medical facilities. IMC has tested Dharma in a remote mode in the USA. They have not deployed a digital tool to manage patient files in the field. They have chosen to use Dharma as it offers the ability to go back to an old record or data point in the collected data.

No NGO has deployed Dharma for registration and follow-up of patients in the field.

4.4.4 Mangologic

Mangologic is a platform developer, but collaborates closely with D-tree to build digital health systems. D-tree is an international NGO that supports other NGO's in strengthening health systems with digital solutions. It has been active for the past 15 years in many countries in Sub-Saharan Africa and Asia. D-tree was an early user of Commcare, but shifted to Mangologic because Mangologic offered more accurate and scalable software.

MSF OCG has developed a mobile health application with Mangologic. This app supports health workers in their diagnostic judgement and clinical decisions for children aged < 5 years. One of the

outcomes is a reduced use of antibiotics, from 87% to 54%. The application is operational in 3 countries. MSF OCBA is planning to deploy the tool in Mali.

The digital health advisor of OCG has previous experience with ODK and Commcare. She decided to switch to Mangologic as the digital platform was more innovative, more accurate, and easier to program and adapt. OCG developed an app to support diagnosis and treatment, called eCare (link)

Mangologic is also used as a mobile assistant to support health-related decision-making in a maternal health program in Zanzibar. The project started in 2011 and has a positive impact on the safety of deliveries. In Liberia, a similar project is piloted by the NGO Open Development LLC to improve the delivery of essential obstetric care (EOC), e.g. from ANC to delivery and from delivery to post- natal care.

All levels and roles of health care provision are included, i.e. health centres, hospitals, clinics, and midwives. The tool tracks regular check-up of mothers and newborns, e.g. to follow the pregnancy and to plan vaccinations. The set-up of the application is similar to the requirements for an app for nutritional programs. The deployed tool is smart and user-friendly.

Open Development LLC explained that the prototype 1 is currently being tested with 50 users. They are using NFC tokens or data carriers to store the patients' data. It works accurately. They also use fingerprinting tools to identify the patient.

Open Development LLC is very positive about Mangologic and D Tree, due to their extensive knowledge and experience in health. They expressed that the organisation is creative and can come up with out-of-the-box solutions. The data platform of Mangologic is easy to use and end users can make small adaptations (when allowed). New functionalities can be incorporated easily.

4.4.5 Conclusion user experience

The platforms of Survey CTO, Commcare, Dharma and Mangologic all have a solid user base. Although Commcare is the most widely used and based on open source software, it is not perceived as a very service-friendly organisation. The Commcare digital tool is more complex to develop (a technician of Commcare needs to help designing and adapting the application, which makes it more expensive). The tool doesn't give the possibility to share data when being off line i.e. it does not meet the full minimum requirements to replace a register book.

Survey CTO, Dharma and Mangologic provide applications that are perceived more easy to develop. All companies have consultants that can support the deployments of these applications.

Survey CTO is an MDC application used in large scientific surveys. However, the tool has not been used for registration and follow-up of patients. Its users are very positive about the accuracy of the tool and the supporting organization.

Dharma is a user-friendly tool to program applications. Their user base in patient management is still small. IMC has tested Dharma for the follow-up of patients and MSF is planning to use it in managing a cohort of patients in the Busra Hospital, Syria.

Mangologic is an MDC platform that has been deployed by a large number of smaller NGO's, who have accomplished satisfactory results in designing applications suitable for maternal health and nutritional programs. This makes Mangologic the only platform with satisfactory experience. MSF

OCG has started using Mangologic as it is more accurate, is easy to alter, and gives better results than other digital tools.

4.5 Considerations for MSF

If MSF wants to deploy MDC tools, there are important management issues to consider, such as costs, data protection and organisational support.

4.5.1 Data Protection

MSF must adhere to data protection regulations, e.g. General Data Protection Regulation (GDPR) of the EU and MSF Health Data Protection Policy (HDPP). The GDPR regulates personal data protection standards, provides methodology to assess all possible risks of privacy breaches in the process of collecting, analysing, reporting, and transferring data, and gives guidelines to prevent privacy breaches. The GDPR applies when electronic personal data is managed or stored in the EU and/or when data is transferred across the EU border. MSF patient data is always transferred across borders, from the project to
Norway (DHIS2), to HQ (Amsterdam, Berlin) and back to the project.

There are various actors in the process of data collection, each with different obligations:
Data controller: the natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of processing personal data. This is MSF's responsibility as pointed out in MSF's Health Data Protection Policy (HDPP).

Data processors: the digital tools that collect, analyse, provide feedback, and often provide standard reporting. In this case there are two data processors: the MDC tool provider and the DHIS2 teams.

Also MSF is implementing a part of the data processing: our staff is collecting, consenting, entering data of the patient (e.g. quantity, accuracy, privacy), monitoring the patient and analysing data, reporting etc. This part of data processing is not discussed here, as it is not dependent on the MDC tool, but more on the rules (access and data transfer), regulations and behaviour of MSF staff (e.g. consenting) and what MSF exactly demands the software providers to do (e.g. concerning retaining information).

This report will only discuss MDC tools in relation to electronic registration in ATFC's (eATFC).
The responsibilities of MSF are not discussed, as this is not specific to eATFC but to any and all data tools used. The checklist used here is based on the summary the complete checklist of GDPR compliance by La Commission National de l'Informatique et des Libertés (link, updated February 2018).

The GDPR rules that are important for the MDC tools are:
1. privacy and depersonalisation of data, limitation of access
2. safety of data flows
3. the patient's rights to see personal data, to have it removed, and to transfer it to another entity (portability, either electronic or on paper).

1. When a tool is said to be GDPR compliant, it usually means that the tool does not store personally identifiable data, e.g. images and names, on devices or servers but that data are de-personalised as much as possible. In an eATFC, some personal data needs to be available so health workers can pay home visits (if necessary). A solution is to register names and addresses on paper and link this to an ID number used in the electronic tool. Another option is to enter the personally identifiable data in the MDC tool and keep these data in the project, i.e. it will not be exported anywhere else. This data needs to be deleted when the patient exits (ID numbers can be kept). Both solutions are possible with the current MDC tools
2. However, MDC tools and providers have responsibilities beyond the depersonalisation of data. MSF needs to ensure that MDC tools are fully GDPR compliant. MDC providers need to have provisions to protect data from privacy breaches, e.g. by offering data encryption, password systems, and server management.
3. Additionally, the tool should be able to provide the patient with their full data-set and it should be possible to delete a patient's data. Provisions should be made that an individual patient's data can be given back to the patient either by an electronic device or on paper. An NFC token or wrist data carrier could be a good choice for a personal health record.

Table 23: Compliance with privacy standards

Compliance with privacy standards	Survey CTO	Commcare	Dharma	Mangologic
EU General Data Protection Policy (GDPR)	In progress	Yes	Yes	Yes
HIPAA (Patient Record Standard)	Optional	Yes	Yes	Yes
Hosted in Europe	In Europe	In USA	In Europe	In Europe
Hosted on a server controlled by MSF	Possible	Possible	Possible	Possible

MDC providers were asked about their compliance to GDPR (as far as the software can facilitate) and to the patient record standards (HIPAA).
The HDPP by MSF determines MSF as the data owner, a role equivalent to data controller. This means that MSF should have the control over access (and the level of access) to data. To execute the controller role means that MSF should have ultimate control over the server where data is processed and stored, and that limited, MSF-only staff have full access to data. Therefore MSF should be the owner of the server. The MDC providers usually host the server capacity, e.g. Commcare in USA, Dharma in Europe, but all MDC providers are able to facilitate hosting on MSF's own servers in Europe.

As shown in tables 14 and 20, all evaluated MDC tools are able to create backups, provide password protection, install automated backup, encrypt data on servers and during transfer, provide logging on after a time period, and host software and data on own server. Table 15 shows that all MDC tools provide editing and deletion of data to a certain extent and table 17 shows that all MDC tools can make at least a print of the register book and can generate a patient card.

Overall, Dharma and Mangologic provide the best features, followed by Commcare and Survey CTO. MSF should make sure that all privacy requirements are included in the contract with the MDC provider.

4.5.2 Expected costs

In addition to technical specifications, we requested estimated prices for a hypothetical case: a pilot to register 12.000 patients over the course of 1-2 years, starting in one project location and adding two more project sites later on. Most providers gave a rough estimate; as Commcare could not offer all requested functionalities (data sharing in offline mode), they did not give a financial estimate. A

data collection tool can be developed if the workflow is adapted to one workstation/tablet to complete a data entry form. The cost estimation for using Commcare was not derived from a formal offer, but from their website and interviews with current users, and keeping the development of a limited application in mind.

It is estimated that there will be five users per ATFC (see also table 1). Health workers (users 1-3)

Table 24: Cost estimate ($) for pilot: 175 data points/1.000 patients/1 year

		Survey CTO	Commcare	Dharma	Mangologic
Initial cost	Creation MDC tool	13.000	25.000	6.000	40.000
Initial cost	Integration with DHIS2	Not specified	Not specified	Not specified	included
Training based on 14 days, excluding travel/stay	HQ and/or field	29.500	29.500	11.200	10.000
	Subtotal initial cost, minimum	***42.500***	***54.500***	***17.200***	***50.000***
Recurring costs/ year	Software/platform licence	18.000	24.000	35.000	No cost
Recurring costs/year	Maintenance software (e.g. on servers)	included	Included	included	7.200
	Subtotal annual costs, minimum	***18.000***	***24.000***	***35.000***	***7.200***

Technical support is estimated at 125 per hour for all MDC providers. Devices and (renting) server space were excluded from this cost estimate.

The cost estimate is not complete and it should be noted that this is a rough and temporary overview. New developments, negotiations and possible changes in pricing strategy all play a role in the final price for a real project.

The pricing strategies of the various MDC providers differ greatly:
- Survey CTO's initial costs are below average (2), their recurring costs are below average (2).
- Commcare's initial costs are highest (4), their recurring costs are above average (3).
- Dharma's initial costs are lowest (1), their recurring costs are highest (4).
- Mangologic's initial costs are above verage (3), their recurring costs are lowest (1).

Based on the initial costs (excluding training) plus the recurring costs for the first year with 7 users/stations and 12.000 patients, the average cost per patient varies between € 2,58 (Survey CTO) and € 4,08 (Commcare).

Dharma charges a relatively high annual fee and states it can justify this price by offering a superior platform. If a project is scaled up, Dharma will be more expensive than any other MDC tool. However, the lower set-up costs of Dharma are profitable when the number of patients is low, e.g. in a pilot.

Dharma offers an enterprise model or yearly licence, limited at € 100.000 per year. If MSF exclusively uses Dharma for all surveys and electronic tools, the price per patient will drop. Using Dharma across all programs and sections (e.g. nutrition, mental health, maternal health, and vaccination) seems tempting, it is not a likely scenario given the independence of the sections and the dynamic market.

The Mangologic platform is built on Google's AI technology. Mango Logic doesn't charge expenses for using the platform/software, only recurring expenses are made for maintaining and storing the software on a (client) server. However, Mangologic charges more for building an MDC tool but are

the only MDC provider who can make tool completely adapted to our workflow. They justify this price by focusing on the added value of their technical and health consultants. Mangologic has low running costs and when a project is scaled up, it becomes more profitable.

Commcare charges the highest price for a tool and an above average price for the platform. The technology used is more complex, which might justify the resources needed to develop an application.

Survey CTO's pricing set-up is reasonable but cannot offer the functionality to share data between users / stations when being offline.

It seems that Mangologic is the best option, from a workflow or field users perspective. On the long run is financially most interesting

Sustainable funding of electronic tools is essential, as two MSF initiatives and several NGO's had to stop development due to management and funding issues. One-off funding to start deployment is usually not the biggest challenge, but the continuation is. Therefore, as the annual running costs are reasonable, Mangologic is an attractive option.

4.5.3 Organisational support

Another important aspect to consider is the available support (see also table 21).
Training of users (online and documentation), technical support (on-site or remote, helpdesk, self-service, and consultants) and automatic updates are assets that limit financial risk and enable a pleasant and efficient workflow.

Dharma and Mangologic score best and are seen as the most customer-friendly and service-oriented firms, delivering regular updates and good technical support. D-tree, the app builder and distributor using Mangologic, has several offices and is able to promptly deliver support, if required on the spot. To receive support from Survey CTO and Commcare is a bit more complicated (unclear on updates, individual advice, general technical support). Despite being the market leader, Commcare does not have a very positive reputation. Dharma and Survey CTO are more centralised and their potential service level in the field is difficult to assess.

Technical possibilities develop quickly, but the needs of MSF can also change very quickly, e.g. reporting requirements, legal developments, patient loads, staff level, and adding more variables. It seems wise to deploy a flexible system. As shown in paragraph 5.2.2 (table 14), Dharma and Mangologic are the most suitable for scaling up, maintenance and updating of the system, changing variables, integration of ITFC 's, integration of other apps (e.g. for vaccination programs), and the possibility to develop a full EMR.

5. Discussion, conclusions and recommendations

This project, the electronic registration of patients in an ATFC, aims to identify an electronic registration tool for outpatient feeding centres (Ambulatory Therapeutic Feeding Centre, ATFC) only. The objective of this electronic tool is to eliminate the use of pen and paper in the registration process, to increase efficiency and accuracy of registration, to enable instant data delivery to management to facilitate decision-making, and to feed directly and instantly into the HIS.

5.1. Discussion

MSF is continuously improving patient care by medical innovation and new models of care and with the deployment of the new HIS also data and reporting tools are on a higher level.
However to improve the entire data chain, quality data collection in the projects needs to be further developed. Electronic data collection could play an important role in this process.

MDC tools have reportedly improved the quality of data, the accuracy, reliability, and timeliness of data collection, aggregation, analysis and reporting. High quality data is the basis to improve operations, to strengthen accountability, improve quality of care and steer innovation. MDC tools can be used for registration, data collection and reporting, but also for diagnosis and treatment support, identification, and instant patient care.

The sapling nursery of MSF OCA gave the opportunity to investigate digital tools for registration and limited follow-up of patients in outpatient settings. This is an important step towards more efficient use of digital solutions. Digital support aims to increase efficiency and guide program management with high quality data and prompt overviews and less manual work, ultimately leading to improved quality of care. High quality data increase monitoring of programs and guides strategies and the challenge is to meet all technical and managerial requirements, and to combine data collections to develop an efficient, informative system that respects the principles of health data protection and humanitarian values[3].

5.1.1 Apps and platforms

This search focussed on an electronic tool to capture patient registration in outpatient services with some patient follow-up. The electronic tool should make use of mobile devices (tablet, smartphone) and function properly without a constant internet connection, called a Mobile Data Collection (MDC) tool.

This research was searching apps for use in the periphery (MDC apps), but soon became clear that that a general platform on which several apps can be developed has many advantages over a single isolated app developed for MSF only. The advantage is that a platform's technical performance is continuously updated, a service level is provided and the platform is not influenced by changes of various individual apps. In addition, certain features are standard available and can be adapted according to needs such as automatic upload to DHIS2 and to the HIS.

On an up-to-date MDC platform, many apps for outpatient health programs can be designed and built and maintained e.g. TB, reproductive health, mental health and nutrition; only the fields for

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[3] Oxfam (Tomkys-Valteri E; 2017) reported on their advancements (august 2017) in combining data silos in a workable data collection and analysis system

data entering needs to be different, the underlying software remains the same. An MDC platform can also be used for apps developed for diagnostic and treatment support, e.g. eCare by MSF OCG. Ultimately, data of apps within one MDC platform can be combined and connected, e.g. an app for registration could be integrated with an eCare app to support diagnosis or with a drugs and food ordering system.

Apps on existing MDC platforms are easier to scale up and it provides advantageous economy of scale compared to specific apps developed for a specific purpose only. The development of an app in-house is not an optimal option as these are not scalable and not sustainable[4] . This is illustrated by the two attractive nutrition apps of MSF, Buendia and Easynut, of which the development is stopped due to funding and/or operational challenges. Restarting the development of these two apps would be challenging as the technical developments have moved too quickly.

All MSF programs follow patients over time, even though this follow-up is very limited (e.g. presence and discharge). Therefore, the MDC tool needed to replace a registration book is classified in the category EMR (Electronic Medical Record). This terminology might be misinterpreted as a heavy system demanding extensive patient data for instant care. Actually, an EMR can be used in a range of activities from bedside instant patient care to admission and outcome data, a light form of EMR (EMR-light).
Although a large number of MDC tools are available that can collect data in a remote or offline environment, most of these tools are developed and used for surveys (one point in time) and not for multiple entries and feedback over time. A small number of electronic tools have been deployed and proven to be suitable to register and follow patients over time. Just one MDC (Mangologic) has demonstrated capacity to share data between users when being offline.

5.1.2 Workflow and instant connectivity

The current paper based data flow is a cumbersome process. Some data are directly entered in the registration book and some data are copied from the patient card in the registration book at the end of the day. Days later data from the registration book and other data collection sheets are manually entered in the master software (the HIS).
As the registration book contains data of different workstations, the MDC should facilitate this process by allowing several users working sharing data following the workflow.
This would imply that all the different health care providers should enter data directly in a mobile device that feeds automatically into the register app, e.g. at reception, at the weighing and measuring stations, at the nursing station.

This implies that some communication between the mobile devices is needed in an offline setting. Near Field Communication (NFC) is possible but not practical, as the devices (tablets/telephones) have to be close to each other. A unique portable identifier like a patient owned NFC token (e.g. chipcard) is the most promising option to share and update data in the same workflow. This can be combined with an unique identifier e.g. by a patient number, fingerprint or with a photo image. In this way the patients literally owns their medical data. Mangologic is most advanced by offering these features and integrate them in the data flow.

5.1.3 The evaluated MDC tools

In this research we have evaluated four platforms that support MDC and two mobile applications that were specifically designed for feeding programs and to follow up patients.

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[4] ' Develop an app yourself, that is an absolute stop' , statement of Oxfam Innovation Team

The list of criteria for evaluation were developed by interviewing potential users, reviewing past experiences (e.g. Buendia) and consulting software specialists. The benchmarking entailed interviews with the software providers, physical testing of the software, and collecting user experiences. In addition, implications for the organisation of MSF were explored.

All tools met the medical data requirements for an ATFC. Reportedly, it is relatively easy to collect or adapt the required patient data. Therefore, this research is not only applicable for nutrition programs, it also applies to tools that track ambulant patients, e.g. in HIV, TB, SBV, ANC, PNC, IMC, Mental Health and vaccination programs.

Differences between the tools surfaced when the technical functionalities were investigated. The two apps developed by MSF, Easynut (MSF B) and Buendia (MSF OCA), scored insufficient on the functional demands, as further development of these apps was halted by MSF.

Of the four MDC platforms, Mangologic and Dharma rated the best on functionalities, closely followed by Survey CTO and finally Commcare. This is related to the basic technical software framework used; Commcare and Survey CTO use ODK and Javascript, while Dharma and Mangologic use a more modern software environment facilitates scaling up, e.g. Google's AI technology (see also table 4). By using Google as database server, Dharma and Mangologic can closely follow the developments in this field, integrate smarter algorithms, and possibly develop 'smarter' MDC tools.

Discussions with users highlighted that Commcare doesn't meet the requirements optimally, despite Commcare is the most widely used tool for registration in feeding programs by NGO's. Commcare is perceived as not flexible, lacks features for patient follow up, difficult to scale up, complex and providing unsatisfactory support.

The Survey CTO tools are of very high quality, but they have only been used for studies and research and not for longitudinal follow-up or care of patients.
The Dharma platform is mostly used to collect data of field operations (surveys and program data), but it has limited operational experience in following patients over time.
Mangologic has deployed apps that enables the follow-up of patients over time in health programs. It also has experience in integrating biometric tools and sharing data tokens with patients using NFC.
Mangologic offers a package that matches the requirements of outpatient health programs .
MSF OCG already uses Mangologic for patient management decisions and found it easy to program, smart and accurate. This mobile tool to support clinical decisions (eCare) is being scaled up.

5.1.4 Organisational considerations

Some important aspects of organisational support were explored. Data protection regulations (GDPR and MSF Health Data Protection Policy) address the entire data flow of which MSF is responsible. Most of these regulations are related to MSF's staff behaviour and contractual demands. MSF is responsible for ensuring that MDC providers are in compliance with these regulations. Therefore, MSF should make sure all requirements for data protection are listed in the contract with the MDC provider, e.g. de-personification rules, passwords rules, access rules, and server strategy. All providers can deliver these requirements, except for Commcare, that still has to do some work to reconfigure their apps.

The other strategic aspect for the deployment of electronic tools is the financial component. A hypothetical use case (virtual project) was given to the tool providers to estimate costs. These are the minimum estimated costs; additional costs might be necessary, pricing strategies may change, but prices may also be lowered as a result of negotiations. Nevertheless, this exercise gives an idea of cost structures and strategies. The initial costs to develop a digital tool exactly matching the

workflow in an ATFC is a serious investment. In addition, the app/platform and database need to be maintained every year, adding to annual recurring costs.

Annual costs and costs for additional requirements can be a problem; For example, World Vision, Save the Children and the World Heart Federation have reduced or halted the deployment of MDC tools (Commcare) due to continuous funding difficulties.

Dharma has the lowest initial development costs (estimated about $ 17.200) and Mangologic has the lowest recurrent annual costs (estimated about Mangologic $7.200 versus Dharma $35.000). The initial costs of Mango Logic are higher (estimated about $ 40.000) because they have integrated the features to facilitate the complete workflow in an outpatient facility, e.g. incorporating possibilities for unique patient identifiers. Dharma doesn't offer this features and is hence simpler and less expensive.

When the annual recurrent costs are added to the initial costs, the total cost for using Mangologic is higher costs compared to Dharma when calculated over the first year, but on the long run the investments in Mango Logic will pay out as the software licence is free.

In the cost estimate, hardware and training are not taken into account. Hardware (tablets, smartphones, desktop computers) and adaptations, legal advice, and guidance will increase the initial cost with $ 20.000-30.000 and the annual cost will increase with a percentage of these hardware costs depending on the depreciation time of the hardware.

We estimate that the investments in electronic tools balance out in roughly two years, after which the tool will save time and money and it will support accurate and prompt data management. A more conservative estimation is three years.

Lastly, the level of support provided is important. Mangologic has a good service record, in part thanks to their cooperation with D-tree who is able to promptly deliver support (on-site if necessary). As an example of a prompt reaction, D-tree offers a package for data collection in outpatient health programs that follows the specifications and terminology of this research, even before the dissemination of this report. Dharma and Survey CTO are more centralised and their service level is more difficult to access. Generally, Commcare does not have a very good reputation concerning their service delivery.

5.1.5 Way forward

Many platforms are developed for different purposes and for various and varying needs while also the technical features are rapidly advancing. Given the complexity of MSF's programming, the related needs, and the rapid change of needs warrants a flexible system. Although it feels convenient to use one particular platform, this might not be the best solution.

CartONG states that the benefits of using one platform, such as in-house expertise, and compliance with organisational standards, the disadvantages of a single platform outweigh these benefits. The use of one platform inevitably leads to organisational inertia, limited flexibility, difficulties to adapt to new developments and needs, and ultimately to frustration of staff (specifically with electronic literate young staff). Cart ONG suggests the deployment of a pool of 3-4 solutions to account for different requirements. (CartONG 2017).

This basic idea is also applied by Oxfam, who works with a variety of MDC tools (Survey CTO and Mobenzi) and used a variety of analysis tools. (Tomkys-Valteri E. 2017)

Similarly, one can envisage that MSF can deploy different tools for use in hospitals, surveys and offline outpatient purposes.

Also in MSF the complexity and variability of programs, flexibility supporting systems (tools) is a requirement to adapt to fast changing needs. This pleads for the use of several electronic tools/platforms. In MSF this would mean that the platforms and tools should be able to connect with one core health platform such as the HIS. As many electronic tools that are interesting for MSF should offers automatic updates, extensive support and training in-house, inhouse IT expertise of each tool is not necessary. Also in this way MSF can profit from economy of scale and swift incorporation of IT developments. Therefore, it is best not to use one single MDC tool and opt for several tools/platforms.

In order to manage a wealth of possible apps and platforms, MSF should develop a framework in which minimum requirements are described, such as technical compliance to connect with the data hub (HIS) and the required support level and training provided.

Despite all possibilities of mobile electronic data tools, it is too early to conclude how these technologies will and can be used in MSF. There is no good insight to weigh the needs and benefits with obstacles, risks, safety and ethical concerns in typical MSF contexts. The expectations of an electronic registration should be evaluated. Does it improve patient care? Does it save time and money? Is it faster, does it give timely overviews, is it more accurate, is it accepted by staff and patients? Can the hardware used for MDC be maintained and can de data be stored and retrieved.

The way forward to develop expertise is to design a pilot including the necessary evaluation indicators to test theory and to inform strategy and policy concerning electronic data collection.

A pilot of a MDC tool should go beyond the minimum of a registration book but cover the entire workflow in order to be effective and prevent copying from paper in the tool. Therefore, the piloted platform should incorporate elements of local connectivity, patient identification, and multiple users in outpatient facilities.

The pilot should also develop, test and fine-tune systems of data protection, safety and acceptability. Requirements related to data protection for the MDC platform should be in a contract with the producers (templates are available) to ensure incorporation in the software. However, a major part of data protection is related to human behaviour and additional measures in the workflow (e.g. consent). Rules of behaviour and additional tools are being developed in MSF, but the feasibility and the practicalities in the field need to be tested and rules need to be adapted accordingly.

While many outpatient programs would qualify (e.g. mental health, reproductive health), a pilot in nutrition has the advantage that the patient flow is quite predictable and described, the number of patients is rather clear and the nutrition advisor is aware of technological developments.

A pilot with on the Mangologic platform is now the best choice as they have already deployed such apps, and therefore Mangologic is simply a step ahead other platforms concerning MDC tools for outpatient health programs. However, fast technical developments go and negotiations with the producer can change the cost benefit balance.
We searched for MDC tools with EMR-light though our networks and internet. Nevertheless, there might be existing MDC EMR-light tools but not currently known by our networks. To enable a proper judgement of current and future platforms, a framework for platforms should be developed including the following elements:
- Supports mobile data collection (MDC)
- Enables longitudinal follow up (light EMR)
- Functions in remote settings with limited connectivity
- Enables several data users simultaneously
- Supports hosting of several apps

- Supports several types of use e.g. registration, EMR and diagnostic and treatment support
- Possibility to link with an unique identifier system (eg chip, finger print)
- Supports automatic feed in the HIS or DHIS2.
- Supports technical requirements for medical data protection
- Has a sustainable service approach

5.2. Conclusion

To follow patients in an outpatient nutritional program, MSF needs a flexible, user-friendly, and scalable MDC platform that complies with GDPR and HDPP and does not have high set-up and recurring costs. Apps designed for a specific use do not meet all the requirements.

Platforms provide an electronic structure that forms a foundation for apps. All platforms support changes of the data fields of the app, which makes it an interesting solution for many programs beyond nutrition, e.g. mental health and TB. Of the evaluated platforms, Mangologic and Dharma received the best evaluation concerning functionalities, flexibility, and costs. Mangologic has the advantage of having experience in limited follow-up of patients in outpatient settings. The service provided by Mangologic is more flexible, possibly due to the service stations in several regions. The financial difference between Dharma and Mangologic depends on the intended use and the negotiations of MSF with these platform providers.

For now, at this moment of exploration, Mangologic fits best the needs of an outpatient health program. Dharma follows but doesn't offer now, but can develop the functionalities related to the follow up of patients.

This ranking is a snapshot at this moment as requirements (e.g. MSF data management), innovations and updates change continuously and rapidly. Therefore, MSF should closely follow the market on several key benchmarks, e.g. functionalities and pricing. MSF should design a framework for identification of suitable platforms in future.

A pilot of an app on a platform would inform MSF's strategy concerning benefits and limitations of electronic data collection, including local data exchange, data protection and feasibility. An app on Mangologic platform would be most suitable as Mangologic has deployed electronic data collection apps for outpatient health programs with other organisations and thus Mangologic is a step ahead other platforms.

5.3 Recommendations

5.3.1 Develop framework for selection of MDC in outpatient health programs

Although it is practical to stick to one specific platform for apps, MSF is very divers, supports a lot of initiatives thus probably various data collection tools (apps) and other health systems will be piloted and adopted. In addition, as this field is changing fast, in future various MDC platforms can and will support the MSF in collecting and registering data. This diversity and flexibility should be channelled by the development of a framework with minimum requirements for these electronic initiatives. These should include requirements of a platform, rules for health data protection, steps for introduction of the app etc.

5.3.2 Pilot an app on Mangologic

To advance the subject of electronic registration in outpatient settings, to inform the eHealth strategy in general, to test tools and support MDC framework development it is necessary to run a pilot with the tools currently developed to apply theory in practice, to learn and adapt when necessary.

The pilot should evaluate functional features such as described in a framework for MDC tools, and the pilot should include process and impact features such as:
- Feasibility
- Acceptability, including authorities, staff and patients
- Costs and benefit balance (e.g. time saved)
- Impact on patient care
- Data protection issues (contract, rules of behaviour)

Currently Mangologic is the best fit for platform that can support apps that follows patients in a remote and off line environment as they already have deployed such systems. This does not mean the MSF should stick to Mangologic, but it seems reasonable to limit risks of bugs and learn as much as in a pilot. Later, when MSF's framework for MDC tools in outpatient settings is clear, similar pilots can be run with other platforms (for instance with Dharma).

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7. Annexes.

7.1. Platforms and tools considered for evaluation

Platforms	Website	Benchmark exercise					Track record with medical NGO's	Focus on longitudinal / case management	Users	Short listed	Comments
		Kopenik	CartONG	OCBA	Manson Unit	Other sources					
Acquee	http://acquee.com				X		Yes	no		no	survey oriented
Akvo Flow	http://akvo.org	X	X				No	no		no	
Buendia	Stopped development					X	Yes,	yes	MSF OCA	yes	EMR developed by MSF OCA for nutrition programs
Commcare	http://www.dimagi.com	X	X	X	X		Yes	yes	Save the Children, World Vision, World Hearth Federation, Terre des Hommes	yes	
Datawinners	https://www.datawinners.com	X					No	no		no	
DeviceMagic	https://www.devicemagic.com		X				No	no		no	
Dharma	http://dharmaplatform.com/		X	X	X		Yes	yes	MSF OCA - Manson unit, OCBA	yes	
DHIS2	https://www.dhis2.org			X	X		Yes	no		no	focus on aggregation and visualization
Easynut	Stopped development					X	Yes	yes	MSF Belgium	yes	light EMR developed by MSF B for nutrition programs
EpiCollect5	https://five.epicollect.net	X	X		X		Yes	no		no	survey oriented
Formitize	http://formitize.com/en/		X				No	no		no	
Fulcrum	http://www.fulcrumapp.com		X	X			No	no		no	focus on location leverage
GoFormz	https://www.goformz.com		X				No	no		no	
iFormbuilder	https://www.zerionsoftware.com	X	X		X		Yes	no		no	

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KoboToolbox	http://www.kobotoolbox.org	X	X	X	X		Yes	no		no	
Magpi	https://magpi.com	X	X		X		Yes	no		no	
Mango Logic / D tree	https://www.mangologic.com			X			Yes	yes	MSF Geneva, OCBA, Open Development, MoH Zanzibar,	yes	
Medic Mobile	https://medicmobile.org			X	X		Yes	yes	Usaid, Rhites, Intrahealth	No	not selected: test crashed ; lack of information.
Mobenzi Researcher	http://www.mobenzi.com		X				Yes	no		No	survey oriented
mWater	http://www.mwater.com		X	X			No	no		No	wash specific
ODK with Aggregate	https://opendatakit.org	X	X	X	X		Yes	no		No	
ONA	https://ona.io		X	X	X		Yes	no		No	
Poimapper	http://www.poimapper.com		X	X	X		No	no		No	focus on mapping
Pushforms	http://www.getpushforms.com/		X				No	no		No	
RapidPro	https://community.rapidpro.io			X			Yes	no		No	community survey oriented
Socialcops Collect	https://socialcops.com/collect/	X	X				No	no		No	only used in limited context so far.
Survey123	https://survey123.arcgis.com		X		X		Yes	no		No	focus on mapping
SurveyBe	http://surveybe.com		X				No	no		No	no considerable track record with humanitarian orgs
SurveyCTO	http://www.surveycto.com	X	X				Yes	yes	Oxfam,	yes	
Vieuwworld	https://viewworld.net	X					Yes	no		No	focus on mapping
VitalHealth	https://www.vitalhealthsoftware.com					X	No	no	Diacare, Mediq	No	interesting focus on applications in our 'modern' world

7.2. Acknowledgements

7.3. Conflict of interest statement

None of two authors and direct collaborators have any affiliation or financial or non-financial interest with a provider of mobile data collection tools that were listed and/or evaluated in this research.

7.4. Disclaimer

This Report (the "Report"), its content, evaluation, conclusions and recommendations have been compiled by Médécines Sans Frontières Operational Centre Amsterdam (MSF OCA) and SC SYNERGIE B.V. based on information provided by several providers of mobile data collection tools and NGO's using these tools (the "Survey").
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