

Efficiency of an Electronic Health Information System for Antenatal Care

A Pilot Time-Motion Study

Marie Hella Lindberg



Main supervisor: Kjersti Mørkrid Blom-Bakke, PhD

Co-supervisor: Knut Reidar Wangen, Dr. polit

Faculty of Medicine: Department of
Health Management and Health Economics

Thesis submitted as a part of the Master of Philosophy Degree in
European Master in Health Economics and Management

UNIVERSITY OF OSLO

June 2017

Efficiency of an Electronic Health Information System for Antenatal Care:

A Pilot Time-Motion Study

© Copyright Marie Hella Lindberg

2017

Efficiency of an Electronic Health Information System for Antenatal Care in Palestine:
A Pilot Time-Motion Study

Marie Hella Lindberg

<http://www.duo.uio.no>

Print: Representeren, University of Oslo

IV

Preface

The thesis is written in collaboration with the Global Women and Children's Health team at the Norwegian Institute of Public Health (NIPH), who are supporting the implementation of an electronic registry (eRegistry) for maternal and child health (MCH) in Palestine. The eRegistry computerises client files and automatises reporting, and includes clinical decision support with interactive checklists.

An on-going cluster randomised trial (eRegQual study) evaluates the effectiveness of the eRegistry for antenatal care compared to paper records in primary healthcare clinics in the West Bank. The main objectives of this master's thesis were to map the workflow in these primary healthcare clinics and subsequently develop a data collection tool. This tool was then used to conduct pilot time-motion style observations. The hypothesis was that the eRegistry is expected to reduce the amount of time spent on health information collection, with the potential to free up time for client care. Efficiency was measured in terms of time spent on health information management among care providers in clinics with the eRegistry compared to those still using the paper-based system. The findings from the pilot study are used to inform and plan a time-motion study in the eRegQual study (eRegTime study) that has better statistical power to detect differences in effect.

Although the nested time-motion study was originally scheduled for the spring of 2017 and was originally expected to be the focus of this thesis, the transition to an electronic reporting practice took longer than projected. Considering that care providers spend a substantial portion of their time with reporting routines, conducting a time-motion study at this moment in time may have led to inaccurate estimates of time. I used this opportunity to design and develop a suitable data collection tool and to conduct pilot observations, given the scarcity of time-motion studies literature in general and in low- middle-income settings in particular.

The pilot time-motion style data collection as well the nested time-motion study will add to the literature as one of relatively few time-motion studies from a middle-income context.

Abstract

Background

Health information in Palestine is fragmented, characterised by repetitive paperwork and duplicated data entry. Palestinian healthcare providers spend considerable amounts of time on maintaining multiple client registers, files and books. The on-going implementation of an electronic registry (eRegistry) for maternal and child health (MCH) is expected to reduce the burden of health information management experienced by care providers. This has the potential to improve their ability to provide healthcare services of high quality.

Methods

This thesis presents the design and development of a study that will investigate whether the introduction of an MCH eRegistry leads to time efficiency. Efficiency will be measured in terms of reduced time spent on health information management in the context of antenatal care in primary healthcare clinics with and without the MCH eRegistry in the West Bank of Palestine. It describes the mapping of care providers' workflow, the development of a data collection tool, and the conduct of a pilot time-motion style study. The time-motion methodology involves continuous observation of care providers' work tasks and recording of the time taken to perform a set of predefined tasks. The results of the pilot study will inform and plan a time-motion study that has the statistical power to detect differences in effect.

Results

The pilot study results suggest that care providers in the clinics with the MCH eRegistry spend more time on both antenatal care consultations and health information management compared to care providers in clinics still using the paper-based system. The sample size was small and not balanced between the two groups. The results were not statistically significant.

Conclusions

The pilot study results suggest that there are no statistically significant differences in time spent on health information management between clinics with and without the MCH eRegistry. The sample size that was estimated to achieve statistical power requires a larger sample size than the number of clinics that are eligible. The MCH eRegistry should be fully implemented and matured before the conduct of the future time-motion study can take place.

Acknowledgements

It is with a bit of melancholy I hereby submit the final product of two plus one highly exciting years in this programme. It has brought me to Mozambique, Switzerland, the Netherlands, Italy and Palestine, and I am incredibly grateful for all these opportunities.

First of all, I would like to thank my main supervisor, Kjersti Mørkrid Blom-Bakke at the NIPH, who has supported me throughout this extremely interesting and challenging process. I am deeply grateful for the opportunity to be involved in this research project, and it has equipped me with a lot of valuable skills and experiences. Kjersti's guidance and feedback throughout these months have been extremely valuable for the completion of this thesis.

I would also like to thank my co-supervisor, Knut Reidar Wangen at the Institute of Health and Society at the University of Oslo. He has been incredibly patient in guiding me in the right direction even when the outcome of this process was rather unclear. His input on methodological aspect has been crucial.

Mahima Venkateswaran at the NIPH has been an enormous support – thank you so much for all the discussions about the Palestine project, politics, feminism and food. Thanks for introducing me to Palestine. Thank you, Binyam Bungudo, for your support in this process, and for being an excellent travel and *fukhara* partner. Thanks to the rest of the team at NIPH, especially Frederik Frøen for letting me take part of the team and for sending me to Palestine. To Tamara Awwad, Khadija Abu Khader, Buthaina Ghanem and Taghreed Hijaz at the PNIPH in Ramallah – thank you for welcoming me with open arms, and for your effort in facilitating our formative research in the West Bank and the conduct of the pilot study.

Thank you, Magne Strømmen, Martine Melgård and Joe Armitage for proofreading drafts of the thesis. Thank you, Aurora Kronberg, Leila Yousif, Maria Maningding and Natasha Bhagat for all the coffee breaks on campus. To all my friends and family, who have tirelessly listened to my moaning during periods of frustrations. And last, but not least, thank you Magne, for your great support and for always standing by me. You are truly a keeper.

Marie

Table of contents

List of figures and tables

List of acronyms

1	Introduction.....	1
1.1	Research objectives	3
2	Review of the literature	4
2.1	Maternal and child health	4
2.2	Information systems in health	5
2.2.1	Obstacles in health information systems.....	6
2.3	eHealth	9
2.4	eRegistry for maternal and child health.....	10
2.4.1	eRegistry for Maternal and Child Health in Palestine	11
2.5	Time-motion methodology.....	12
3	Material and methods.....	16
3.1	Study setting	16
3.2	Eligibility criteria	17
3.3	Study design.....	18
3.3.1	Workflow mapping	18
3.3.2	Task categories.....	24
3.3.3	Data collection tool	25
3.3.4	Time-motion observations	26
3.4	Statistical analysis	27
3.4.1	Power calculations	29
4	Results.....	31
4.1	Results of pilot observations.....	31
4.2	Power calculations.....	34
5	Discussion.....	35
5.1	Pilot time-motion observations.....	35
5.1.1	Strengths and limitations.....	40
5.2	Methodological considerations.....	41
5.2.1	Workflow mapping	41
5.2.2	Sampling and sample size	41
5.2.3	Data collection tool	42
5.2.4	Time-motion method	43
6	Implications and recommendations	47
6.1	Workflow	47
6.2	Data collection tool.....	49
6.3	Time-motion study implications	50
7	Conclusions.....	52
	References.....	53
	Appendices.....	59
A.	Ethical clearance documents	59
B.	Training manual for observers.....	62
C.	Stata outputs	68
D.	Suggested Time and Motion Procedures (STAMP)	74

List of figures and tables

Figure 1:	22
Figure 2:	23
Figure 3:	25
Table 1:	27
Table 2:	31
Table 3:	32
Table 4:	32
Figure 4:	33
Figure 5:	48
Figure 6:	49
Figure 7:	50

List of acronyms

ANC: Antenatal care

CRCT: Cluster-randomised controlled trial

DHIS2: District Health Information System version 2

eHealth: Electronic Health

eRegistry: Electronic Registry

HIM: Health Information Management

HIS: Health Information System

MCH: Maternal and Child Health

MDG: Million Development Goals

mHealth: Mobile Health

MoH: Ministry of Health

NIPH: Norwegian Institute of Public Health

PHC: Primary Healthcare Clinics

PNIPH: Palestinian National Institute of Public Health

SDG: Sustainable Development Goals

WHO: World Health Organisation

1 Introduction

Health information systems are becoming increasingly important on the global health agenda. They are vital in health system strengthening, in monitoring the sustainable development goals (SDG) and in achieving universal health coverage (1-3). However, many countries face challenges in establishing reliable and timely collection, analysis and use of health data, which impedes evidence-based decision-making (4). The presence of vertical and donor-led programmes leads to parallel information systems, which incurs considerable costs and sustainability challenges for national health systems. This creates inefficiencies, duplication and uncoordinated data systems with healthcare personnel facing significant amounts of paperwork. A potential consequence is that time for actual patient care is shortened (4, 5).

A response to the need to improve efficiency and timeliness in the collection and use of health data, are electronic registries (eRegistries). An eRegistry seeks to increase the availability and timely use of routine data in order to improve the quality of care and health outcomes around the world (6). The eRegistry assists care providers at the point of care with interactive checklists and clinical decision support, based on evidence-based guidelines that are adapted to the local clinical workflow (7).

In Palestine, a nationwide eRegistry for maternal and child health (MCH) is currently being implemented. Palestine, which consists of the West Bank including East Jerusalem, and the Gaza Strip, has a population of 4.75 million inhabitants, of which 2.9 million live in the West Bank and 1.85 million in the Gaza Strip (8). Palestine faces many health challenges similar to those of other middle-income countries, but performs rather well compared to other Arab countries (9). Palestine has a young population with about 40 per cent below the age of 15 (10). This indicates a relatively high fertility rate, at 4.1 children per woman (8), combined with falling infant mortality rates (9, 11). In 2012, life expectancy at birth was 74.4 years (12). The Palestinian population is undergoing an epidemiological transition, in which non-communicable diseases such as cardiovascular diseases, diabetes, cancer and hypertension have replaced communicable diseases as the main causes of mortality and disability (9). Maternal and child health outcomes have gradually improved over the course of the last decades. According to the Palestinian Ministry of Health (MoH), the maternal mortality ratio was in 2015 at 15.7 per 100,000 live births; the under-5 mortality ratio at 13.9 deaths per

1000 live births; and infant mortality was at 10.9 per 1000 live births (11). The share of women attending at least four ANC visits was at 95.5 per cent in 2015 (12).

Healthcare providers in Palestine maintain various record books and paper forms, and spend considerable amounts of time entering information into multiple registers. Anecdotal evidence suggests that care providers spend about one third of their time on tasks related to documentation and reporting, possibly affecting the ability to perform quality healthcare services. The MCH eRegistry is implemented in order to increase the efficiency of patient care, data collection and reporting, and it has the potential to reduce the burden of health information management experienced by care providers.

An on-going cluster-randomised controlled trial (CRCT) is embedded in the nationwide implementation of the MCH eRegistry in Palestine. The CRCT's outcomes are the effectiveness of the eRegistry's interactive checklists and clinical decision support on improving the provision of timely and appropriate screening and management for important conditions during ANC, and health outcomes for the mothers and new-borns (13). The study population in the CRCT is primary healthcare clinics offering ANC services reporting to the MoH. The unit of randomisation is individual primary healthcare clinics (PHC), or for the smallest units, clusters of two or three PHC. The trial includes 133 PHC, of which half are allocated to the intervention arm, and the other half serving as the control, using the current paper-based system. The intervention is interactive checklists with clinical decision support for ANC within the MCH eRegistry, which allows for seamless incorporation of clinical workflow and guideline support in addition to reminders of daily clinical procedures and referrals.

The implementation of health information technologies has the potential to have a significant impact on clinical work processes and workflow (14). There are various methods, both qualitative and quantitative, for studying workflow according to the context and research objectives. The focus in this thesis will be on a quantitative method, namely the time-motion method, which is considered an accurate method for quantifying care providers' time allocation (14, 15). Numerous studies have documented how the introduction of an electronic tool affects care providers' workflow (14, 16). However, these are predominantly limited to high-income contexts. Workflow studies have rarely been conducted in primary healthcare settings in a middle-income country context such as the one in Palestine.

This thesis describes the workflow mapping, development and testing of the data collection tool and the conduct of pilot observations for a time-motion study. The data collection tool and the findings from the observations will be used to develop a study protocol for a time-motion study.

1.1 Research objectives

The overall aim of the thesis is to design and develop a time-motion study that investigates whether and the extent to which the introduction of an MCH eRegistry in Palestine leads to gains in efficiency in terms of reduced time spent on health information management in the context of ANC in PHC in the West Bank of Palestine.

The future time-motion study will assess the comparative efficiency of the MCH eRegistry in terms of care providers' time allocation by means of the time-motion method (17). It seeks to assess whether the MCH eRegistry has the potential to relieve care providers of the “the drudgery of paper work” (4) by means of the time-motion methodology. The planned study will add to the literature as one of relatively few studies assessing the impact of an electronic health (eHealth) intervention on clinical workflow and time allocation in a middle-income context.

The objectives of this thesis is to 1) test the training material and data collection tool developed for the Palestinian setting in a pilot study applying the time-motion methodology; and 2) make power calculations based on the results from the pilot study observations, which will ensure that the time-motion study will be powered to detect a significant difference between the clinics using the MCH eRegistry and those still using the paper-based system.

2 Review of the literature

2.1 Maternal and child health

The Millennium Development Goals (MDG) led to increased focus on and progress in MCH outcomes. However, by 2015, the MCH-related MDG remained largely unmet (18). For example, global estimates suggest that by 2015, the global maternal mortality ratio was at 216 per 100,000 live births, corresponding to a reduction of 43.9 per cent from 1990 (18), clearly falling short of the MDG 5's target of 75 per cent. Unmasking the various factors leading to poor MCH outcomes is urgently needed if the SDG are to continue where the MDG left off. However, the quality of existing data is poor, and the sharing and dissemination of information within MCH are substandard (19), thus complicating the identification of underlying factors. These gaps are further exacerbated by the fact that the countries with the poorest MCH outcomes also tend to have the weakest health information mechanisms targeting the most vulnerable populations (18, 20). This, in turn, complicates the classification of disability and deaths and thus increases the risk of misclassification of health outcomes (18).

Arguably, one reason for the difficulties in identifying the underlying factors behind poor MCH outcomes is the nature of the most commonly reported indicators in MCH, such as ANC coverage and skilled attendance at birth. Although important, they convey no information about the process and content of care, nor do they capture the causes for e.g. low ANC coverage. Contact indicators like these are therefore inadequate for the comprehensive measurement of MCH outcomes (21). An alternative indicator that sets out to measure effective coverage in terms of “(...) the proportion of the population who need a service that receive it with sufficient quality” has been suggested (21). Such an indicator could potentially overcome the information gap on quality in MCH. It could further contribute to identifying suboptimal clinical practices in the care process and, as such, detect where efforts should be focused in order to improve outcomes.

Comprehensive indicators in MCH combined with robust monitoring and evaluation systems has the potential to facilitate the implementation of evidence-based interventions in MCH (19). This is important in promoting information systems that produce data with the potential to inform local efforts to improve gaps in care and patient outcomes (19).

2.2 Information systems in health

Reliable health information is imperative in delivering improved outcomes not only within MCH, but in health in general. In this regard, robust, comprehensive health information systems are essential.

Health information systems are highly diverse, and so are the contexts within which they operate. Health information systems have been described as “integrat[ing] data collection, processing, reporting, and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services” (22). At the individual and community level, information systems are a prerequisite for effective clinical management and for evaluating whether services are responding to community needs and demands. At the district level, they are important for the effective functioning of health facilities. At the top level, health information is used for strategic policy planning and allocation of resources in the sector (23). Given the effective functioning of the health information system at all these levels, data collection is used for evidence-based decision-making.

Health data collection methods can be divided into routine and non-routine systems (22). Routine systems collect data directly from clients and patients in health facilities and institutions at regular intervals (5, 24). Routine system sources are typically composed of individual health records, records of service-delivery, and of health system resource records (24). Routine health data collection methods are to a large extent built on data based on the healthcare services provided in the facility, and provides information on the health of the people using the regular health services (5). Examples include health services and programme reporting, administrative data, and civil registration and vital statistics (25).

Non-routine systems consist of data collected at irregular intervals from surveys, demographic surveillance and other specialised studies (26). Examples include the Demographic and Health Surveys (27), population censuses, and impact evaluation studies (25). These types of surveys are in many instances driven by donor and vertical programmes’ need to establish baseline indicators relevant for their outcomes (28). Although non-routine systems have the potential to inform routine systems for decision-making, the irregular

intervals for data collection, the aggregation structure of the data, and the type of information collected, leave limited scope for basing decisions and policies on data collected by non-routine methods alone.

2.2.1 Obstacles in health information systems

There are various factors that lead to poorly performing health information systems. One of these arises in one of health information systems' key components, namely the information process. The information process can be divided into the following five steps: data collection, data transmission, data processing, data analysis, and presentation of information for use in planning and managing the health services (29). In short, it is concerned with transforming raw data that can be utilised for decision-making (29). In many instances, however, the information process is characterised by disruptions in several of the abovementioned steps. Health information systems are in many instances fragmented, characterised by inadequate health data collection systems, resource constraints, and low incentives to collect health information, leading to health system ineffectiveness and inefficiencies (4). For the information to flow seamlessly across these steps, an appropriate management structure of the health information system is required.

An underlying factor in poorly performing health information systems is the way routine health data collection methods are constructed. Routine methods presuppose actual utilisation, and are heavily biased towards those who have access to services, and those who do not have access are left uncovered (26). This is evidently a challenge in low- and middle-income settings, in which large segments of the population have low access to and use of health services. Routine health data collection methods are often rendered inadequate in poorer parts of the world where the lack of reliable health information is the most severe (20). The resulting information gap that prevails in many countries has to some extent been compensated by the use of non-routine systems, such as resource-intensive household and community-based surveys (23, 30). It has been argued that the investment and emphasis on surveys, that are predominantly externally funded, has "(...) enabled donors and developing countries to sustain their neglect of the development of comprehensive and sustainable national health information systems" (30). Harmonisation across the various survey methodologies has been encouraged (30), but strengthening health information systems

requires substantial fortification of routine information systems that are grounded and integrated into national health systems (1).

Even if the role of robust information systems in producing successful health outcomes has been acknowledged in both the MDG and the SGD (1, 2), there has been a tendency towards prioritising the production of data for programme- or disease-specific indicators among aid donors (31). This is often linked to the presence of vertical programmes.

A vertical programme can be said to have the following properties: First, “specific, defined objectives, usually quantitative, and relating to a single condition or small group of health problems”; second, “the objectives focus on the short or medium term”; and third, “it has centralised management and discrete means”, such as staff, vehicles and funds (32). Vertical programmes tend to focus on only one specific disease or objective, and are common practice among donors, due to their desire to achieve quick, measurable results to report back on (32). Separate reporting systems are therefore often implemented in parallel with the pre-existing national health information system, without integration into the wider health system. This might lead to significant inefficiencies in terms of duplication and fragmentation: “(...) donor-driven and disease-specific initiatives have actually undermined efforts to develop a comprehensive HIS [health information system] by creating separate, parallel, and often duplicative systems to meet the need for each funding source” (30).

A potential result of duplication in health information systems, is fragmented care, double-entered data and an inadequate ability to track and quantify the care provided to the client (33).

Vertical programmes are particularly prevalent in low- and middle-income contexts in which external aid donors play a large role in the health sector, in the sense that they are the main source of financing (30). As donors become increasingly influential in setting country health sector priorities, national health systems are gradually left disempowered in terms of planning and priority-setting (32). Escaping this situation is difficult due to the reliance on external financing. In some instances, these factors lead to implementation of health programmes and interventions that in many cases do not respond to the actual needs of the population due to the lack of timely and relevant information (4).

Health information collection is for many care providers associated with substantial loads of paperwork, “(...) filling endless registers with names and addresses of patients, compiling information on diseases (...) every week or every month, and sending out reports without adequate feedback” (22). Care providers spend considerable amounts of time collecting overlapping and redundant information, and they often have to collect information that is irrelevant to them, which is likely to affect the motivation to ensure that the collection of data is of adequate quality (22). The amount of different forms and record books care providers have to maintain for various purposes is further likely to affect the quality of data. As a result, the processing of data is delayed, leading to a substandard use of the collected information at the cost of evidence-based planning and decision-making.

In sum, healthcare providers have to relate to separate programme systems, which cause considerable double work, incurring additional costs and inefficiencies at the various levels in the health system. Such inefficient healthcare delivery is wasteful. Waste can be defined as the “use of resources without benefit to the patients a system is intended to help” (34). According to the Institute of Medicine, there are two ways of reducing waste: First, by reducing quality waste, and second, to reduce administrative and production costs (34). Examples of quality waste are clinical and medical errors and overuse of health services. Waste in administrative costs is for example unnecessary clinical processes and multiple data entries (34). Thus, there is reason to believe that fragmented and duplicated paper-based information systems that require substantial amounts of time spent on health information management incur considerable avoidable administrative costs.

Due to the ever-growing need to contain healthcare costs within the health sector, “[e]fficiency in information management is becoming increasingly essential because of the concern for cost control in services and the way service staff spend their time” (35). Waste in health information management is not necessarily solely caused by waste in the resources themselves, but also through the ways in which staff manage them.

Countries miss out on the potential that lays in robust health information systems in facilitating planning and promoting cost-efficient priority setting. The same is true for the opportunities provided by the increase in digital solutions for health information systems (31). A health system providing universal access to good quality health services without being exposed to financial hardship requires a strong and responsive health system acting in

accordance with population needs. For this reason, an effective and efficient health information system integrated into the national health system is crucial. Further exploring the role of eHealth to turn this tide is therefore in its place.

2.3 eHealth

Electronic health (eHealth) has the potential to play a significant role in improving quality of care (34). eHealth can be defined as the “use of information and communications technologies in support of health and health-related fields” (36). eHealth solutions include various health technology tools, such as electronic medical records, telemedicine, health information systems, mobile health technologies (mHealth), and electronic decision support systems (37).

eHealth tools add to paper-based information management the ability to make data timely and immediately available for analysis, and as such facilitate the use of data (6). eHealth has the potential to make the flow of client information more efficient (33). It enables improved collection, analysis and use of health information, thus reducing duplicate activities, costs and waste of time and resources. As such, eHealth could contribute to minimise the already severely resource-constrained health systems’ spending on expensive health data collection (6). In maternal and child health, eHealth eases the individual follow-up of women during the period of pregnancy and childbirth, and information sharing and communication across levels of care and health personnel in the care process is improved (6).

The existing evidence on the impact of eHealth solutions in low- and middle-income countries is to a large extent limited to pilot initiatives that are not integrated into the wider health system (38). Without a clear strategy for institutionalisation, eHealth efforts are likely to suffer from unreliable investments and fragmented implementation efforts (38). Although many eHealth initiatives demonstrate a beneficial impact on clinical care processes, the evidence from resource-poor settings on the effects of eHealth services on patient outcomes remains limited (39), especially within the field of maternal and child health (40, 41). This could partly be due to the poor quality of data and scant evidence on implementation effectiveness of eHealth-based information systems (41).

It is imperative to ensure that the implementation of eHealth technologies do not end up as fragmented efforts separately from the wider health system. A long-term focus on continuity and quality of care must be maintained throughout the implementation. Only in this way will eHealth efforts be able to provide coherent and secure information that follows individuals across all levels in the health system (6).

2.4 eRegistry for maternal and child health

The eRegistry Initiative is developed by the Norwegian Institute of Public Health (NIPH) in collaboration with the World Health Organisation's Department of Reproductive Health and Research. The aim is to develop a joint framework for evidence, guidance and technical tools to facilitate the development and country implementation of eRegistries for reproductive, maternal, new-born and child health in low- and middle-income countries (6).

eRegistries are developed in participation with healthcare personnel on a free and open source software that can be accessed on any technological platform. It assists the care provider at the point of care with interactive checklists and decision support, tailored for the local workflow and developed from evidence-based guidelines. Client care is shared between different healthcare workers across the gestational, labour and postpartum period. The eRegistry allows for single data entries to be structured into a systematic and uniform information system with the ability to streamline all mHealth applications. For the client, the eRegistry is built to send personalised SMS messages with appointment and treatment reminders, laboratory test results and behaviour change messages based on health status and risks. For care providers, the eRegistry personalises work schedules, automatically aggregates and reports to the health authorities and supervisors, provides feedback based on performance, generates referral and discharge documents, and sends real-time communication about individual clients to and from other providers in the system. Health system managers and supervisors have real-time access to systems performance indicators, facilitating the prediction of healthcare delivery and supply needs in order to set priorities and designing appropriate policies (7).

The eRegistry acts as a viable and cost-effective alternative for coherent data management, facilitating collection, analysis and use of data. It is expected that the replacement of the paper-based documentation system with the MCH eRegistry will reduce duplicate data entry

and thus minimise time spent on documentation and reporting, leading to reduced administrative costs. Additionally, improved flow and access to timely and reliable information will improve the abilities to identify, plan, implement and monitor relevant interventions within MCH. The system's clinical decision support and interactive checklists are expected to reduce the risk of clinical error, and as such, quality waste will be reduced. Thus, the benefits of the eRegistry are anticipated to be substantial, and there is a large potential for improved delivery of quality healthcare. The eRegistry could therefore serve as an example of a health information technology improving the quality of healthcare along the lines of safety, effectiveness, patient-centeredness, timeliness, efficiency and equity (34).

2.4.1 eRegistry for Maternal and Child Health in Palestine

The Palestinian National Institute of Public Health (PNIPH) and the Ministry of Health are currently implementing a nationwide eRegistry for MCH built on the DHIS2 tracker software, a flexible web-based open-source information system (42). It provides a viable alternative to the current, paper-based system in Palestine in that it collects all data entry points in one place, reduces the risk of care provider error, and the use and analysis of data from all levels of care are facilitated (7).

The health information system in Palestine has been characterised as fragmented, with a range of gaps in data collection and quality that weakens the ability of the government to reach their goal of strengthening the health system and improve the public health situation in the country (12). The means of data collection are poorly coordinated with unreliable availability (43), and data are often left under- and unused (12, 44). As such, there is a clear need for improvements in collection, analysis and use of health data (45).

The implementation of the MCH eRegistry is one of several measures taken by the Palestinian Ministry of Health with the aim of increasing efficiency of patient care, data collection and reporting for decision-making in health (46). Whether and how workflow and time allocation in ANC consultations is affected by the MCH eRegistry is yet to be investigated.

2.5 Time-motion methodology

Workflow research in health has increasingly gained importance in the literature over the recent years. Mapping how staff spend their time has the potential to identify possible efficiency gains in work processes. As such, workflow studies seek to investigate the effect of the introduction of health technologies on healthcare personnel's workflow (16).

There is no general definition of workflow or what methods to apply in a given research context, which makes it difficult to generalise across studies. This is because workflow research is highly context-dependent, "(...) due to the interaction between contextual elements and work activities" (16). Both qualitative and quantitative methods are applied, such as time-motion studies, work sampling and time efficiency questionnaires. The quantitative time-motion method is considered a reliable method that produces accurate results in assessing care providers' workflow (14).

Time-motion studies were first applied in industrial engineering for addressing inefficiencies and waste on material resources, where it was found that the primary inefficiency loss was not due to material, but the waste of human effort (47). Originally, it was described as a method aiming to improve efficiency and as such establish productivity standards for workers. The tasks performed are broken into steps, and "(...) the sequence of movements performed by the subject to accomplish those steps is observed to detect redundant motion, and precise time taken for each movement is measured" (47). The term has further developed and diversified, leading to some confusion with regards to what time-motion studies are and what they are not. Some studies that claim to be time-motion studies actually use other methods, such as work sampling (14). A review of time-motion studies that excludes methods strictly not living up to the definition of the time-motion method as using "an observer to record exactly how much time is being devoted to each task" (48), identified the following two features: first, the recording and/or analysis of the time required to perform a set of tasks; and second, the continuous capture of data performed by an external observer (47). With this definition, a time-motion study can inform how the introduction of an electronic tool influences clinical workflow by quantifying care providers' use of time and delimiting how their time is distributed across different types of care- and non-care-related activities (14).

Time-motion studies have increasingly been used in healthcare over the past decades (14). The methodology is used to quantify and assess the workflow in a given context. In some instances, it is applied purely to quantify workflow in order to identify the potential for efficiency gains (49), or with the aim of evaluating how workflow changes with the introduction of a new work practice, such as a new model for clinical care (50). However, the method is more commonly applied to evaluate whether and to what extent health information technology increases efficiency (51). Time-motion studies are moreover widely applied to assess information technologies' impact on quality and costs (47). As such, the methodology allows for comparing the allocation of care providers' time before and after or with and without the introduction of a health information technology.

Time-motion studies involve continuous observation and recording of the time taken to perform a set of tasks by independent observers (47). The identification of tasks should be based on a carefully mapped workflow. Workflow mapping refers to the activity of defining the sequence of tasks, how they relate to each other, and the resources needed to carry them out in order to understand a work process (52). This commonly serves as the basis for the design of the time-motion data collection tool. Rigorous training in advance of the observations is essential, and observers must be familiar with the clinical context and the workflow. The time-motion study hypotheses should be masked to the observers in order to reduce the risk of bias. The observer utilises a predefined list of tasks adjusted to reflect the relevant clinical context and workflow. The most commonly utilised tool for the collection of time data is electronic tools that contain a list of activities, with the ability to automatically time-stamp these activities as the observer clicks the task button corresponding to the observed activity (17, 53). Other studies use stopwatches and a paper form with a predefined list of tasks (50, 54). The latter is arguably less reliable than the former, since it entails more action from the observer, thus increasing the risk of inaccurate reporting.

A common research question in time-motion studies is whether the introduction of an electronic tool has a negative impact on the workflow in terms of more time spent on the tool compared to the paper-based system, as this is a common concern (16, 17). Partly due to the various contexts within which these studies are conducted, the existing time-motion literature is ambiguous in answering research questions like these (14). Furthermore, the design, conduct, and how results are reported in existing studies vary to a considerable degree, which makes comparison across studies difficult (14). As a response to this, a checklist for the

standardisation of time-motion studies has been proposed to facilitate comparison across studies in terms of study design, conduct, and methods for reporting results (14).

Two papers from a primary healthcare clinic setting in the US are central in the time-motion literature (17, 53). They both hypothesise that the introduction of an electronic health tool will consume more time compared to a paper-based system. In the first one, it was found that using the computerised system did lead to a minor increase in time spent per patient, but that time spent on the tool decreased as physicians gained more experience. It was expected that time would be saved over time. There were also improvements in the workflow in terms of less duplication and simplified access to and availability of information, and physicians received feedback and reminders from the system (53). The second study builds on the design of the former, with adjusted task categories. Here, the authors found no statistically significant change in time spent after the implementation of electronic health records. Time spent outside consultations was not observed, which is likely to be affected by the introduction of electronic health records (17). Both studies use staff surveys to complement the results from the observations. This provides additional information on the users' perception of the tool, and can to some extent act as a cross-verification technique (16).

Key contributions to the literature are the development of a time-motion data collection tool that was utilised in these two studies, made available by the Agency for Healthcare Research and Quality (51), and the rationale behind the construction of the task categories (17, 53). Later studies (49, 55, 56) have applied a similar approach, which eases standardisation of design, conduct, and results reporting in time-motion studies.

Most time-motion studies are limited to primary healthcare contexts in the US or other high-income settings, while the contribution from low- and middle-income contexts is limited. One study assessed the allocation of care providers' time after the introduction of a new model for antenatal care in Tanzania (50). Another example is a study that evaluated the potential for improved quality of care in HIV clinics in Uganda by examining workflow and patient activities (49). In a study from Ethiopia so-called health extension workers were observed in order to understand their responsibilities in the workplace and evaluated their allocation of time across health and non-health activities (57). However, time-motion studies evaluating efficiency gains as a result of an eHealth tool are rare. One of few examples is a study from 24 study sites in Tanzania and Ghana evaluating the effect of the introduction of

an electronic clinical decision support tool for antenatal care and delivery in rural primary healthcare facilities. The authors found that the time needed for ANC did not increase, and sites in Ghana experienced partly streamlined workflow, which demonstrates the potential of electronic decision support systems to have a positive influence on the quality of care (54). Another example is a time-motion study from the Mosoriot Rural Health Centre in Kenya, in which an electronic medical record system was implemented (58). It comprised a patient registry, a reporting function and a data dictionary. The data dictionary included a list of terms, diagnoses, and drugs. The time-motion study found considerable changes in workflow after the implementation of the system. For patients, time spent with healthcare providers and waiting time was significantly reduced. For care providers, time spent with patients and time spent interacting with other staff decreased, and they tripled their time spent on personal activities. The reduction in time spent on the interaction between the patient and the care provider was likely due to less time spent on duplicating patient information. Overall, the results demonstrated the potential for eHealth systems to improve the quality of care in developing countries, in spite of the additional challenges that come with fewer available resources (58).

The current implementation of the MCH eRegistry in Palestine provides the context for a time-motion study evaluating the effect on care providers' time allocation in clinics offering ANC. A time-motion study in the Palestinian setting will contribute to the literature as one of few time-motion studies from a middle-income country, demonstrating the potential for conducting time-motion and workflow studies also in settings with fewer resources.

3 Material and methods

3.1 Study setting

MCH forms an important part of the healthcare system in Palestine (44). However, the quality and content of MCH care are reported to be poor, and Palestinian women are often dissatisfied with the maternity services they receive in governmental clinics (59). The gaps between recommendations for MCH care and actual practices result in wasted resources and suboptimal health outcomes (44). A shortage of nurses, midwives and MCH specialists, combined with heavy workloads and low salaries in the public health sector, effectively hamper the care providers' ability and motivation to offer comprehensive and patient-centred services (44).

Health information in the public primary healthcare sector in Palestine has up until now been entirely paper-based and has to a large extent been characterised by repetitive paperwork and duplication. Healthcare providers have to enter the same information into multiple registers, and substantial amounts of time are spent consolidating and coordinating reports (25). This might in turn lead to discontent and frustration among healthcare workers. This could compromise their ability to provide quality of care and generate dissatisfaction among the clients.

Palestinian public primary healthcare clinics are classified into four levels that reflect their capacity in terms of available healthcare personnel, the number of clients they receive and the availability of laboratory and ultrasound services. Clinics that do not offer lab and/or ultrasound refer their clients to other PHC that provide these services. Most MCH doctors "rotate" and spread their days of the week across different MCH clinics. Doctor availability determines when the clinics are open for ANC. The number of MCH nurses or midwives at each clinic is also subject to variation. ANC consultations consist of booking and follow-up visits. A booking visit is the first ANC consultation of the pregnancy, and is typically more time-consuming than a follow-up visit, as the client must be registered and her medical, surgical, obstetric and family history must be taken (55). The recommended number of ANC visits throughout the pregnancy is four (60).

The MCH eRegistry, built on the web-based DHIS2, functions both as an electronic medical record registry and as a clinical decision support tool, with interactive checklists linked to daily clinical procedures, referrals and reporting routines. It computerises client files, appointment calendars, and automatise analysis and reporting (7). The interactive checklists include the same items and data points as the current paper-based files, and are built on Palestinian MCH guidelines. The MCH eRegistry has been installed on desktop computers to be used by care providers in the consultation rooms in all the intervention clinics.

In principle, it is only the MCH Handbook, lab, and ultrasound forms that remain paper-based after the introduction of the MCH eRegistry.

3.2 Eligibility criteria

All primary healthcare clinics from the CRCT, being 133 level 2 and 3 PHC offering ANC located in the governorates of Bethlehem, Jenin, Nablus, Ramallah/Al-Bireh, and Salfit, in addition to 31 PHC located in the governorates of Tulkarem, were eligible for this study. To capture both booking and follow-up visits, PHC that have no booking visits on an average working day were excluded from the current study. The second exclusion criterion was that PHC should not have more than one care provider performing ANC on the same woman on the same day. After applying these criteria, there were 83 PHC that remained eligible (31 intervention PHC and 52 control PHC).

Workflow mapping was conducted in six primary healthcare clinics of which three were using the MCH eRegistry and three using the current paper-based system, in the Ramallah/Al Bireh and Bethlehem governorates. The clinics visited were selected by means of purposive sampling – a nonprobability sampling technique in which subjects are not selected randomly, but rather based on a specific purpose, namely to achieve comparability between two types of subjects (61).

For the time-motion pilot observations, six primary healthcare clinics offering antenatal care were selected, of which three were intervention clinics and three were control clinics, in the Ramallah/Al Bireh and Tulkarem governorates in the West Bank of Palestine. They were similarly selected by means of purposive sampling. One care provider was observed at each primary healthcare clinic. The MCH eRegistry was implemented in the intervention clinics in

the period between June and October 2016. As a health systems research study, there were no eligibility criteria related to individual women's characteristics or outcomes.

The clinics had received a letter in advance, informing them about the purpose of the observations: to document the time spent on activities during antenatal care service provision. It was highlighted that only the time spent on different activities would be assessed, not the quality or content of the consultations. The outcome of interest was not revealed. All care providers agreed to be observed. All clients consented to let the observer be present during the consultation.

The study was approved by the Palestinian Health Research Council (Appendix A1), and reviewed by the South East Regional Committee for Medical and Health Research Ethics in Norway (Reference number: 2017/400, Appendix A2).

3.3 Study design

3.3.1 Workflow mapping

Face-to-face semi-structured interviews were conducted in March 2017 with five care providers from clinics that use the MCH eRegistry and five care providers from clinics with paper-based case notes. In semi-structured interviews, the interviewer uses an interview guide prepared in advance, but lets interviewees interact and to some extent guide the direction of the interview (62).

We asked questions about their daily routines, the order of the activities in the clinics, and task sharing among care providers. In the clinics using the MCH eRegistry, we specifically asked about the use of the MCH eRegistry and its effects on clinical workflow. An exercise with card sorts for daily clinical routines was conducted, in which the care providers were asked to place cards, each corresponding to an ANC activity, in the order corresponding to their daily routines.

Some of the field visits conducted during formative research were dedicated to making videos for training purposes. The care providers in the clinics were asked in if they would be willing to take part in a video that would solely be used for training purposes. Given their consent, they were filmed whilst performing their usual ANC activities as if in a real

situation, with an employee from the PNIPH acting as the pregnant woman. The exercise made use of various ANC scenarios in order to capture situations likely to take place in a real setting. These simulation videos were used for the training of observers.

Based on the interviews with care providers and the simulation videos, the following workflows were identified among care providers in the control and intervention clinics. It is nevertheless important to keep in mind that there will always be variations between care providers and from clinics, indicating that the following overview is only suggestive.

Current workflow in control clinics

The care provider normally checks the scheduled appointments in her appointment book, before she lets clients into the consultation room (Figure 1). In booking visits, the care provider opens the ANC client file when the results from lab tests are ready. The client file includes the woman's name, personal ID number, socioeconomic information, obstetric information, medical and surgical conditions and family history of diseases. Typically, the care provider follows the order of data points in the client file, asking about and documenting the client's personal information, her past medical, surgical and obstetric history. The care provider attaches the lab results to the client file. Given the client's last menstruation date, the care provider calculates the estimated date of delivery. Following this, the care provider fills the personal ANC record, called the MCH Handbook, which she gives to each woman during booking visits. It contains all pregnancy-related information and health education, which the care provider fills for each ANC visit. The care provider will also document the woman's information in a register book that the care provider maintains for reporting purposes. The information collected until this point informs the care-provider's assessment of the woman's risk profile and whether she must be referred or not (Figure 1: curved arrow), since women identified with risk factors should be referred to a high-risk clinic. The care provider will complete the necessary documentation and move on to the clinical examination, and if necessary, vaccination. Clinical examination involves measuring the blood pressure, height, weight, pulse, pallor, fundal height, oedema, temperature, breast examination, assessing foetal presentation and engagement, foetal heart sound, etc. Some of these procedures are performed only at certain visits, depending on the gestational age.

In a follow-up visit, the care provider assesses the woman's MCH Handbook, and retrieves the client's file. She will ask and document whether the woman has experienced any

pregnancy-related annoyances or worries since the last visit. Clinical examination and vaccination are performed, before the results are documented in the client file and the MCH Handbook. If the care provider deems it necessary to refer the woman to a high-risk clinic or hospital offering management for high-risk cases, the care provider will call the high-risk clinic in order to inform them about the client, and she will fill out a referral form in consultation with the doctor. The care provider will instruct the woman on which clinic to go to and when, and counsel her on any other aspect related to the referral that the woman must take into consideration. The care provider fills out the relevant information in the MCH Handbook, the client file and the register book, before the consultation is over. The care provider will organise transport of the client file and the referral forms to the high-risk clinic by car.

If the client is not deemed to be high-risk, the care provider will counsel and educate the client. This could be on aspects such as the process of pregnancy and its complications, danger signs, diet and nutrition, rest, exercise, personal hygiene, use of drugs or supplements (e.g. iron and folic acid), care of breasts and breast-feeding, symptoms and signs of labour, plans for delivery and postpartum care, family planning, and harmful habits (e.g. smoking). By the end of the consultation, they will schedule a time for a new appointment, which the care provider writes in the appointment book. The care provider attaches all lab, ultrasound, dental orders and result forms to the client file.

At the end of the workday, when all client consultations are finished, the care provider fills out the daily statistics ANC book, with information on all the women attending ANC on that day. This information is drawn from the register book, and forms the basis for the monthly reporting to the Ministry of Health.

Current workflow in intervention clinics

The identified workflow in the intervention clinics was largely similar to the one described for the control clinics (Figure 2). The points that were different are the following: The care provider typically starts with the MCH Handbook and writes down all personal information and history. The care provider might make the decision on the woman's risk profile at this point, before entering the information from the MCH Handbook into the MCH eRegistry. Automatic messages might appear on the screen depending on the values that are entered,

which could prompt the care provider to act accordingly, or she might choose to ignore the messages if she has already made the decision on the woman's risk profile.

In follow-up visits, the care provider will assess the woman's MCH Handbook, before she retrieves the client's file in the MCH eRegistry. The care provider enters the results into the MCH eRegistry as well as in the MCH Handbook. Referral is performed electronically. If, according to the MCH eRegistry's algorithms, the woman should be referred, an alert will appear and suggest a high-risk clinic for referral based on proximity. The referral of the client's file is automated in the system, and the care provider will call the high-risk clinic to inform them about the client. If the care provider ignores the messages, she must "explain" to the system why she does not follow its suggestions.

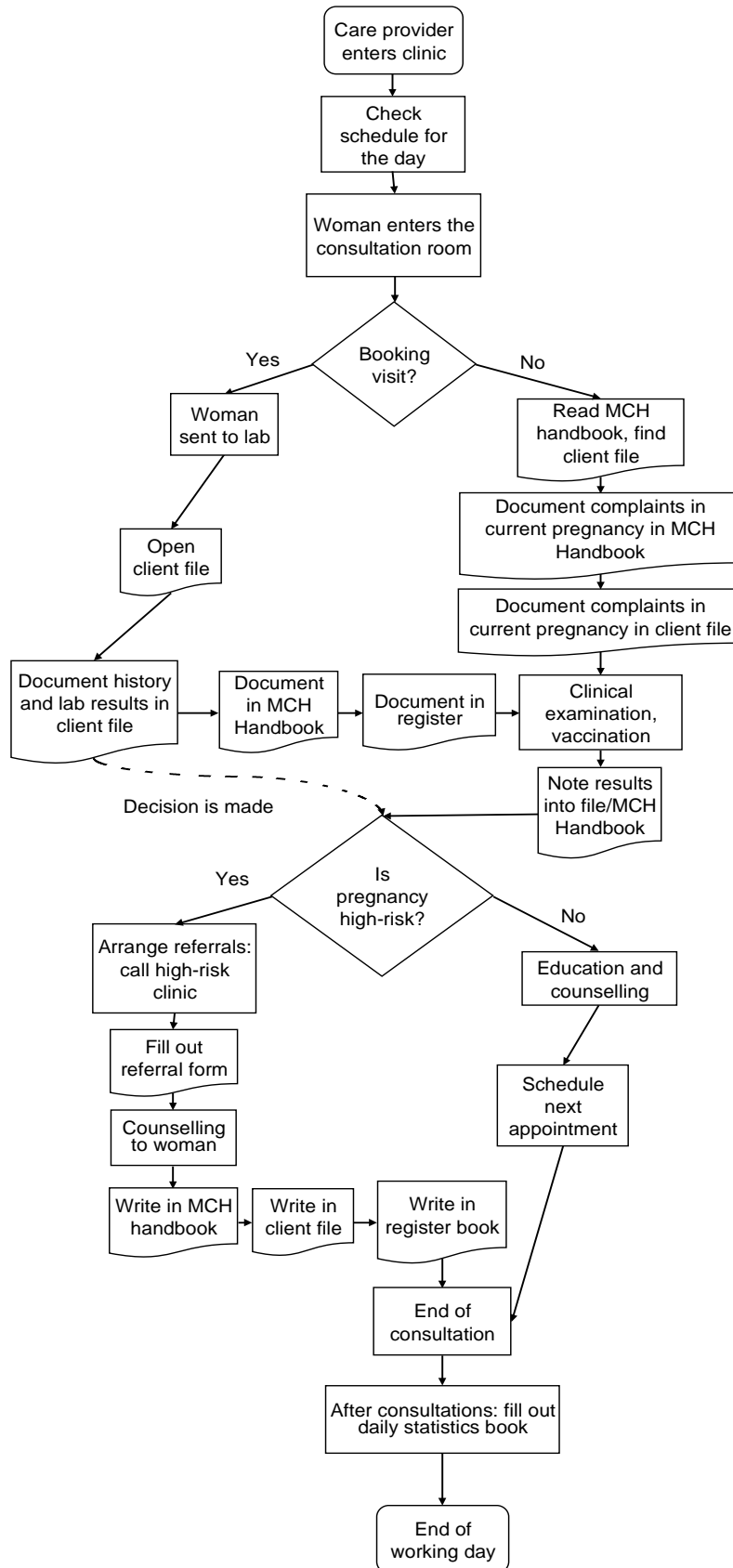


Figure 1: Workflow process chart, control clinic, adapted from ASQ (63). The curved arrow demonstrates the point at which in the process care providers make decisions with regards to the client's risk profile.

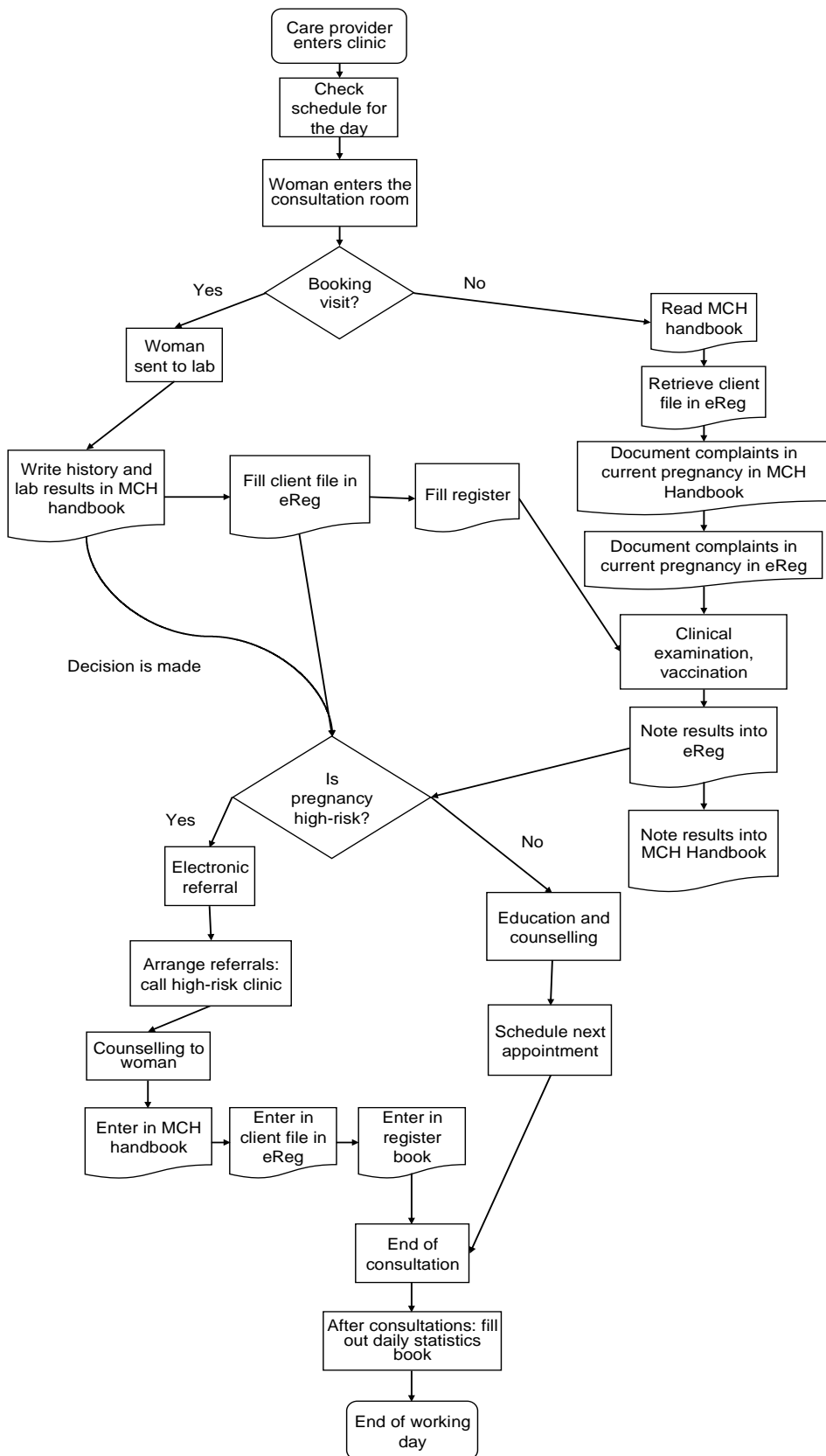


Figure 2: Workflow process chart, intervention clinic, adapted from ASQ (63). The curved arrow demonstrates the point at which in the process care providers make decisions with regards to the client's risk profile.

3.3.2 Task categories

A list of ANC tasks reflecting care providers' workflow was developed. Discussions with PNIPH staff and the observers, and the workflow process charts were used to define the care provider tasks. The tasks had to be visually identifiable for the observer without having to interfere with the care provider. The task categories were designed to mask the observers to the outcome of the study. The structure of the task categories was adapted from Pizziferri et al. (17), in which activities are divided into major and minor task categories. The major ones reflect the physical activity done to perform the task, serving as the category headings in the data collection tool (Figure 3), while the minor categories are the actual tasks performed. Combined, these constitute the total amount of tasks performed by the care providers. The care provider's physical action determines the overall classification of tasks (17).

The major categories were meant to facilitate the identification of the tasks performed. For example, the major category "Paper – Writing" was followed by minor categories related to writing on paper, such as in the MCH Handbook. If the care provider was performing multiple tasks at the same time, such as taking the woman's history at the same time as she was writing down the information in the woman's file, the activity would be classified as "Paper – Writing – client file," and not "Talking – history-taking."

The categorisation of the tasks was separated according to whether the task was computer- or paper-based, which explains the "Read," "Find," and "Writing" categories on both computer and paper. This leaves open the possibility that the care providers in the intervention clinics use both computer and paper. There are more tasks in the "Paper – Writing" category than in the "Computer – writing" category. This is because there are still some activities that are done on paper in the clinics, such as the MCH Handbook. The tool will capture the extent to which care providers have familiarised with the MCH eRegistry, by assessing how much time they spend on it. Evidently, there will be no entry in the "Computer" categories in the control clinics.

ID	ISSI	Date	08.05.2017	Time	14.15.31	Now	Activity	33	Comment:		Observation #:	0
Computer - Find	Talking	Procedures	Computer - Writing	Computer - Read								
<ul style="list-style-type: none"> ↳ Client file ↳ Lab/ultrasound results 	<ul style="list-style-type: none"> ↳ Education and counselling ↳ Talking to family ↳ History: demographic and medical ↳ Test results from lab/ultrasound ↳ Clinical support ↳ Call client/family ↳ Referrals ↳ Technical support ↳ Other 	<ul style="list-style-type: none"> ↳ Clinical/medical examination ↳ Injections/bloodtake ↳ Giving tablets ↳ Other 	<ul style="list-style-type: none"> ↳ Client file (including history) ↳ Lab/ultrasound form ↳ Schedule appointment ↳ Text message in eRegistry 	<ul style="list-style-type: none"> ↳ Appointment list ↳ Client file ↳ Lab/ultrasound results ↳ Guidelines, treatment ↳ Other info 								
Paper - Find		Outside	Paper - Writing	Paper - Read								
<ul style="list-style-type: none"> ↳ Client file ↳ Lab/ultrasound results 		<ul style="list-style-type: none"> ↳ Assisting doctor ↳ Examination in other room 	<ul style="list-style-type: none"> ↳ MCH handbook (including history) ↳ Client file (including history) ↳ Register book ↳ MCH handbook/register book ↳ Register book/client file ↳ Client file/MCH handbook ↳ Lab/ultrasound/prescriptions/referrals ↳ Schedule appointment ↳ Writing on other paper 	<ul style="list-style-type: none"> ↳ Appointment list ↳ MCH Handbook ↳ Client file ↳ Lab/ultrasound results ↳ Guidelines, treatment, official letter ↳ Other info 								
		Between/after consultations										
		<ul style="list-style-type: none"> ↳ Writing in statistics book ↳ Group education ↳ Cleaning, arranging files ↳ Phone/computer: personal 										
CLOSE											CONFIRM ENTRY	

Figure 3: Screenshot of the data collection tool (data entry form) used for the time-motion test observations.

3.3.3 Data collection tool

The data collection tool was based on a Microsoft Access database template made available online by the Agency for Healthcare Research and Quality (51). The tool was installed on laptops that were used for data collection.

The observation was initiated at the point in time in which the observer clicked on any task on the data entry form. The observer determined the nature of the current task, and clicked on the relevant task on the form (64). If a task was selected by mistake, the observer could click on the correct one, as the task and its corresponding time interval were not stored until she clicked “Confirm entry.” The observer was therefore free to change the task if the observed task was not immediately identifiable. If the observer did store a task incorrectly, the “Comment” field in the data entry form would be used, and the observer could type the task she actually observed. The “Confirm entry” button marked the end time of a task. The start time of the new task was recorded as the point in time in which the observer clicked on a new task button. To end the observation, the observer clicked “Close.”

The data collection tool template has various functions. It is possible to add information about the observers, care providers and clinics participating in the study, together with the observation date and the number of observations. In order to avoid any confusion for the observers, they were trained to only use the opening screen and the data entry form.

The data collection tool is not able to capture more than one task at the time. The observers were trained in selecting the principal activity that would take precedence over other activities when the care provider was carrying out several tasks simultaneously. For example, if a nurse were counselling the woman on the nutritional considerations at the same time as taking the woman's blood pressure, this would be recorded as "procedures – clinical and medical examination." Only if the nurse is exclusively counselling the woman will this activity be stored as "talking – education and counselling."

The time was automatically stored with second's precision. The data on time and the number of client consultations observed were stored in an attached database, which constituted the data used for the analysis. No information related to the client or the care provider was collected.

3.3.4 Time-motion observations

Three female PNIPH employees with backgrounds in nursing and public health conducted the time-motion observations in May 2017. Both booking and follow-up visits were observed. One of the observers conducted three days of observations: two in control clinics and one in an intervention clinic; the second conducted two, one in each arm; and the third observer conducted one day of observation in a control clinic.

Training of the observers took place prior to the observations during two half days in April of 2017. Prior to the training, they received a training manual describing how the observations would take place, the intuition and explanation of each of the task categories, and how the data collection tool works (Appendix B). The time-motion methodology was carefully presented and discussed, before the content of the data collection tool was thoroughly explained in terms of what ANC activities the tasks correspond to. The observers familiarised themselves with the tool and where on the data entry form the different tasks were situated. They provided their feedback, and the tool was changed accordingly. Lastly, while watching the simulation videos, the observers tested the tool to time-stamp all the observable activities. Observers were instructed to mark whether the consultation was a booking or a follow-up visit in the tool by adding a comment in the data entry form. The observers were asked to observe the care providers' entire workday, including after-consultation work and in case the

care provider performed other types of services, in order to capture the full scope of care providers' tasks.

3.4 Statistical analysis

The primary outcome for the time-motion observations was time spent on health information management per care provider per consultation. Health information management is defined as all tasks involving accessing, documenting and reporting health information. Information access refers to all activities that involve seeking and finding relevant information. Information documentation captures all tasks that involve writing down client information, except writing that involves documentation with the purpose of reporting, which was analysed as information reporting. The primary outcome aims to reflect time spent on client-related “paperwork,” since the MCH eRegistry is likely to affect the way in which care providers handle information sources, not only in pure writing or typing, but also in terms of retrieving, reading, and seeking new information. The primary outcome was analysed by comparing the mean time spent on health information management in the intervention clinics with the time spent on health information management in the control clinics.

For the analysis, the tasks were classified into the following categories: information access, information documentation, information reporting, information processing, client care and miscellaneous (Table 1). As with the task categories, the analysis categories are adapted from Pizziferri et al. (17). Information access, documentation, and reporting are described in the previous paragraph as health information management. Information processing refers to all activities that involve assessing and reading written or spoken client information. The client care category includes all activities in which the care provider has her full focus on the client without any writing, such as clinical examination, education and counselling, etc. Miscellaneous refer to activities that are not related to the client, including personal activities, such as eating, going to the toilet, or tidying and preparing the consultation room for new clients.

Table 1:
Major, minor and analysis categories. Adapted from Pizziferri et al. (17).

Major Category	Minor Category	Analysis Category
Computer - Find	Client file	Information access
	Lab/ultrasound results	

Paper - Find	Client file	
	Lab/ultrasound results	
Talking	Education and counselling	Client care
	Talking to family	Information access
	History: demographic and medical	Information processing
	Test results form lab/ultrasound	Information access
	Clinical support	
	Call client/family	Information access/processing
	Referrals	Information processing
	Technical support	Information access
Other	Miscellaneous	
Procedures	Clinical/medical examination	Client care
	Injections/blood-take	
	Giving tablets	
	Other	
Outside	Assisting doctor	
	Examination in other room	
Between/after consultations	Writing in statistics book	Information reporting
	Group education	Client care
	Cleaning, arranging files	Miscellaneous
	Phone/computer (personal)	
	Other: praying, eating, toilet, etc.	
Computer Writing	Client file (including history)	Information documentation
	Lab/ultrasound form	
	Schedule appointment	
	Text message in eRegistry	Information reporting
Paper - Writing	MCH Handbook (including history)	Information documentation
	Client file (including history)	Information reporting
	Register book	
	MCH Handbook/register book	
	Register book/client file	
	Client file/MCH Handbook	
	Lab/ultrasound/prescriptions/referrals	
	Schedule appointment	
Writing on other paper		
Computer - Read	Appointment list	Information processing
	Client file	
	Lab/ultrasound/results	
	Guidelines, treatment	
	Other info	
Paper - Read	Appointment list	
	MCH Handbook	
	Client file	
	Lab/ultrasound results	
	Guidelines, treatment, official letter	
	Other info	

In addition to the primary outcome, secondary outcomes were: first, differences in ANC consultation time; second, differences in time spent in each of the analysis categories; and third, differences between booking and follow-up visits in the two arms. The study did not seek to measure the time spent on each, single clinical procedure, which is why some of the tasks are rather general, such as the “Clinical/medical examination” category.

The unit of measurement was time in minutes, and the duration of a task was measured by subtracting its start time by the start time of the subsequent task. The outcomes are reported as the average time spent on health information management, average ANC consultation time, average time in each of the analytical categories, and average time spent in booking and follow-up visits.

After-consultation work was recorded as a separate observation. For the analysis, the after-consultation time that was spent on client-related documentation and reporting, was divided by the number of ANC consultations on the same day. The amount of time spent on after-hour work was then added to the average time spent per client. It was assumed that the care provider spent, on average, an equal amount of time on after-consultation work per client.

All the statistical analysis was performed using Stata version 14.2. Descriptive characteristics are presented as the number of observations with the mean, and standard deviation (SD) or the median and interquartile range (IQR), as appropriate. Differences between groups were tested for significance using two-sample t-tests for normally distributed continuous variables and the Wilcoxon rank-sum tests for non-normally distributed continuous variables. In order to identify the confidence intervals, bootstrapping was applied with 5000 replications. The resulting confidence intervals provide the range within which there is 95 per cent confidence that the true value of the population mean is located.

A confidence level of 95 per cent was chosen. However, due to the small sample size and variability in the data, it was not expected that statistical significance would be achieved.

3.4.1 Power calculations

The power of a test is the probability of detecting a statistically significant difference when such a difference exists. This corresponds to the probability of failing to reject the null

hypothesis when the alternative hypothesis is true (65). The data from the pilot observations provided the basis from which to calculate statistical power to detect a difference between the time spent on health information management in control and intervention clinics. With a 95 per cent confidence level, these data were used for calculating the sample size required to detect a power of 80 per cent. This served as the basis for the sample selection for the planned time-motion study.

However, since the distribution of the data was skewed, and the power test assumes a Normal distribution, the data were transformed into a logarithmic scale. A two-sample t-test assuming unequal variances of the log-transformed data was performed. The resulting means and standard deviations were used for estimating the power and sample size ($\alpha = 0.05$).

The power and sample size calculation was performed in Stata version 14.2 using the *power twomeans* command.

4 Results

This chapter presents the results of the pilot study and thereafter the power calculations for the planned time-motion study.

4.1 Results of pilot observations

A number of 51 ANC consultations were observed in six clinics over six days of observation (Table 2). One care provider in each of the clinics was observed, corresponding to six observed care providers. The annual enrolment of new pregnancies ranged from 47 to 571 women. The median number of annually enrolled pregnancies was 97. Thirty-nine ANC consultations were observed in the control clinics, and 12 ANC consultations were observed in the intervention clinics. The average number of observed ANC consultations per care provider was 8.5.

Table 2:
Number of observed antenatal care (ANC) consultations per clinic, mean and median time (minutes) spent on ANC consultations and health information management (HIM).

Allocation	ID	Observations	ANC consultation time		HIM time	
		n	Mean	Median	Mean	Median
Control clinic	1	4	21.9	22.1	5.9	6.3
	2	10	7.6	7.0	5.1	4.9
	3	25	13.4	9.2	6.0	4.7
Intervention clinic	4	7	11.1	8.7	7.2	5.6
	5	1	38.3	38.3	8.7	8.7
	6	4	26.7	27.7	11.4	11.5

Information documentation and miscellaneous consumed most of the care providers' time related to the analytical categories, in both control and intervention clinics (Table 3). The miscellaneous category includes personal activities, and between and after-consultation tasks, which might vary considerably between clinics and care providers. There are notably fewer observations of tasks interpreted as miscellaneous, especially in the intervention clinics.

Table 3:

Mean (standard deviation) and median (interquartile range) time in minutes spent in analysis categories, and number of observations, in control and intervention clinics.

		Analysis category	Control			Intervention		
			n	Mean (SD)	Median (IQR)	n	Mean (SD)	Median (IQR)
ANC	HIM	Information access	27	1.7 (1.1)	1.0 (1.4)	11	1.1 (1.0)	0.8 (0.8)
		Information documentation	38	4.5 (4.2)	3.3 (3.3)	12	7.0 (4.9)	5.4 (8.6)
		Information reporting	25	1.0 (1.2)	0.5 (0.7)	7	1.3 (0.8)	1.0 (1.4)
		Information processing	11	0.5 (0.5)	0.5 (0.5)	3	1.2 (0.7)	0.9 (1.3)
		Client care	34	3.4 (2.2)	2.6 (2.6)	12	1.7 (0.7)	1.7 (0.7)
		Miscellaneous	17	7.3 (6.7)	5.9 (10.7)	1	9.00	9.0 (0.0)

Care providers in the control clinics spent a shorter median ANC consultation time compared to the intervention clinics: 8.9 vs. 15.5 minutes, respectively (Table 4), and shorter median time spent on health information management per ANC consultation, 4.7 vs. 6.3 minutes respectively. The median health information management time as a proportion of total ANC consultation time was 53 and 41 per cent in control and intervention clinics, respectively.

Table 4:

Descriptive statistics for ANC consultation time, health information management (HIM) time and time spent in booking and follow-up visits for control and intervention clinics, respectively.

	Control			Intervention		
	Observations (n)	Mean (SD)	Median (IQR)	Observations (n)	Mean (SD)	Median (IQR)
ANC consultation time	39	12.7 (10.8)	8.9 (9.6)	12	18.6 (11.7)	15.5 (19.6)
HIM time	39	5.8 (4.2)	4.7 (2.9)	12	8.7 (6.0)	6.3 (10.1)
Booking visits time	4	24.8 (16.5)	22.1 (24.9)	4	19.5 (10.3)	19.9 (12.9)
Follow-up visits time	35	11.4 (9.3)	8.8 (8.7)	8	18.2 (13.1)	14.6 (17.3)

The distribution is skewed (Figure 4). There is a wider spread of observed durations in the intervention group, especially above the median. For the control group, there are three

outliers in both the ANC consultation time and health information management time. This indicates that some of the consultations lasted considerably longer compared to the majority of the observations in the sample, and that care providers spent more time on health information management in some of the consultations.

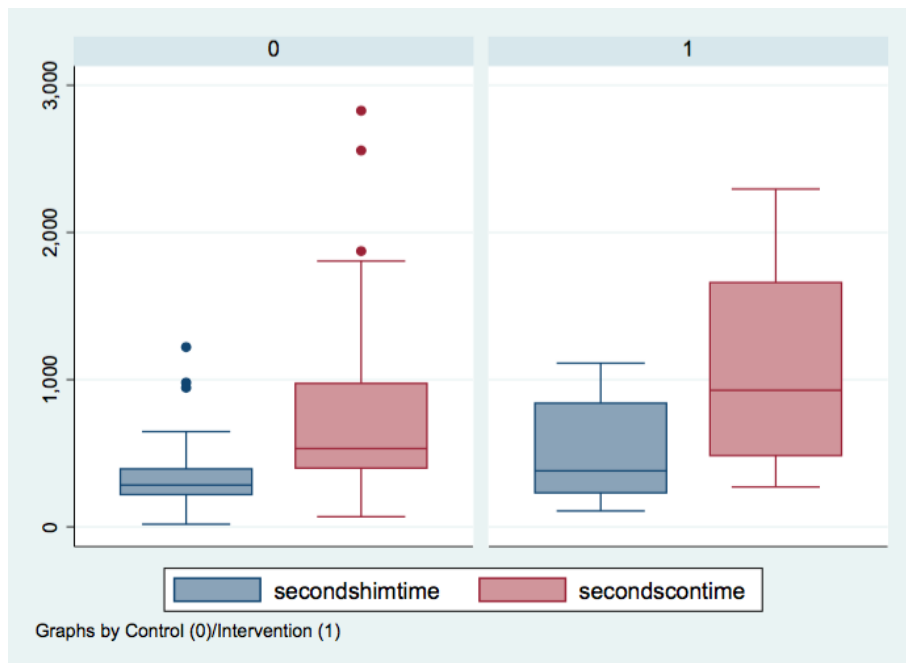


Figure 4:
Boxplot of the distribution of time consumed by health information management (blue) and total ANC consultation time (red), control (=0) and intervention (=1). Y-axis: time in seconds.

For the time care providers spent on ANC consultations in control clinics, the resulting bootstrapped confidence interval was [9.4, 16.1]. For intervention clinics, the bootstrapped confidence interval was [12.0, 25.2]. The bootstrapped confidence interval for the time spent on health information management was [4.4, 7.1] for care providers in control clinics. For time spent in intervention clinics, the bootstrapped confidence interval was [5.3, 12.1].

Running the Wilcoxon rank-sum test on the difference between care providers' time spent on ANC consultations in control and intervention clinics, the data result in a p value of 0.10, which means that the medians are not statistically different at any level smaller than 10 per cent (see Appendix C1 for the Stata output). The difference between the two groups was therefore not statistically significant.

Running the same test for the difference between care providers' time spent on health information management, the medians are not statistically different for levels below 14.3 per

cent, given the p value of 14.3 (see Appendix C2 for the Stata output). The difference between the two groups was therefore not statistically significant.

The Wilcoxon rank-sum test on the difference between the time spent in each of the analysis categories (Appendix C3) in control and intervention clinics proved that it was only the client care category that showed a statistically significant difference in medians (p value: 0.02).

4.2 Power calculations

Before the power and sample size estimations were performed, the outcome variable of interest, namely time spent on health information, was transformed into a logarithmic scale. A two-sample t-test assuming unequal variances of the log-transformed data resulted in means of 5.6 in the control arm, and 6.0 in the intervention arm (Appendix C4). The standard deviations of time spent on health information management were 0.80 and 0.74, respectively. The two arms' sample sizes of $n_c = 39$ (control) and $n_i = 12$ (intervention) observations produced a sample ratio of 0.3 between the two groups. The power of the test with the current sample of $n = 51$ observations was calculated ($\alpha = 0.05$). The power calculation led to an estimated power of 28.2 per cent for the pilot study (Appendix C4).

Following this, sample size estimations were conducted for the time-motion study. The results from the pilot study were used to calculate a sample size to detect a minimum difference between care providers' time spending on health information management in the control versus the intervention group. It was estimated that 60 observations would be required in each of the groups, with 120 observations in total, to detect a minimum difference of 3 minutes between the two groups ($\alpha = 0.05$, power: 80 per cent) (Appendix C4).

5 Discussion

There are various angles from which to study the effect of an eHealth tool. One of them is the time efficiency aspect, which could act as both a facilitator and a barrier to eHealth implementation (15). The aim of this thesis was to design, develop and pilot a time-motion study that investigates the MCH eRegistry's potential for time efficiency in an ANC context in Palestine. This section will discuss the results of the pilot study and how they can be interpreted in light of the study's aim, in addition to methodological considerations.

5.1 Pilot time-motion observations

The time-motion pilot study sought to test the data collection tool and to identify whether there was a difference in time spent on health information management between clinics with and without the MCH eRegistry. Health information management is here defined as all tasks involving accessing, documenting and reporting health information.

It was found that the median time spent on health information management by care providers in the intervention clinics was 1.6 minutes more compared to the control clinics (4.7 and 6.3 minutes in control and intervention clinics, respectively). In terms of ANC consultations, the median duration was 6.6 minutes more in the intervention clinics compared to the control clinics (8.9 versus 15.5 minutes in control and intervention clinics, respectively). Health information management time as a proportion of total ANC consultation time constitutes 53 and 41 per cent in control and intervention clinics, respectively. This suggests that the care providers in the intervention clinics spend relatively less time on health information management compared to the care providers in the control clinics, even if the absolute duration is longer. These results are not statistically significant, as demonstrated by overlapping confidence intervals and large p values: there is not enough evidence to reject the null hypothesis of no difference between the time care providers' spend on health information management in the intervention clinics compared to the control clinics.

These findings are consistent with other time-motion studies that seek to evaluate whether the introduction of an eHealth tool is associated with an increased workload for the care providers. Most studies find no such a statistically significant difference (17, 53-55), which could suggest that the benefits of an eHealth tool can be achieved without substantial

increases in workload. Nevertheless, the prevailing concern that computerising work processes leads to a heavier workload on health personnel is grounded in evidence suggesting that eHealth implementations in some instances are associated with increased time consumption (15, 66).

A study conducted in Ghana and Tanzania compared the effect on time allocation in ANC booking and follow-up visits of an electronic clinical decision support tool pre and post implementation. It was found that the median time spent in booking visits was 10.3 minutes, and 5.2 minutes in follow-up visits pre-implementation. After the implementation of the tool, the duration of ANC consultations was approximately 22.4 minutes (mean time in Ghana: 19.2 minutes; Tanzania: 25.5 minutes). For the post-implementation results, it was not distinguished between booking and follow up visits (54). Although difficult to compare, the tendency observed in Palestine supports these results. The median duration of booking visits was 22.1 minutes and 19.9 minutes in control and intervention clinics, respectively. The reason for reduced time spent in intervention clinics might be due to the MCH eRegistry's drop-down list that could facilitate documentation of client information, as compared to writing it in paper files. For follow-up visits, the median time spent by care providers in control clinics was 8.8 minutes, and 14.6 minutes in intervention clinics. This increase could be due to the clinical decision support component of the MCH eRegistry, which provides a management plan to the care provider based on the entered values. Assessing the management plan and acting upon it might consume more time compared to the static paper-based information system. This suggests that post-implementation, the MCH eRegistry's clinical decision support might consume more time owing to its features. These features ultimately aim to improve the quality of care. Furthermore, data collection and analysis might be improved, which has the potential to facilitate increased evidence-based decision-making. As such, the results might not report any gains in care providers' time efficiency, whereas there might be substantial benefits for the care process and the health system.

Both the findings from the pilot study and the Ghana and Tanzania study diverge from the recommended duration of booking and follow-up visits as suggested by the WHO. For a booking visit, the recommended duration is 30-40 minutes, and for follow-up visits, a duration of approximately 20 minutes is recommended (60). Intervention clinics are close to this recommendation, while the control clinics seem to diverge considerably.

It is worth noting that the observed consultation time is not equivalent to the total time provided to each woman, as the doctor performs parts of the consultation, which we did not observe. Therefore, based on these data, it is not possible to conclude whether the recommended duration for ANC consultations is met.

Health information management time included the time consumed by accessing, documenting and reporting of information, in which documenting was the main contributor. Information documentation consists of all tasks involving writing and typing (except writing in the register and the statistics books). Documentation took the care providers using the MCH eRegistry more time compared to the care providers in the control clinics. They also spent more time in reporting and processing of information, and on the tasks classified as miscellaneous. These findings were not statistically significant.

There are different angles from which to assess why documentation consumes more time in the intervention clinics than in the control clinics. One possibility is that documenting in the MCH eRegistry might be more time-consuming than writing on paper due to the system's features: the response from the system might prompt more action from the care provider. Following this argument, it has been highlighted that eHealth tools' potential to facilitate the management of client information and care will introduce "new" activities that are not included in paper-based systems. These tasks might consume more time due to the system's features and clinical decision support aimed at improved quality of care (17). The logic is that keeping all client information in one place would ease data entry and management with potential for time savings, but the additional components of the system might consume more time, as mentioned in the case of differences in the duration of follow-up visits. It is therefore not necessarily a weakness that the MCH eRegistry consumes more time.

Another aspect to consider is that care providers might not entirely have incorporated the use of the MCH eRegistry into their workflow. The clinics using the MCH eRegistry implemented it between June and October 2016. This would correspond to a period of six to ten months between the implementation and the pilot study, which have been considered adequate for work routines to stabilise post implementation in previous studies (17, 55). Nevertheless, there is no established optimal time period for studying efficiency of eHealth tools after implementation in the literature (15). One study that assessed the potential for a learning effect, found that staff spent less time on data entry in the eHealth tool as they

became more experienced over time (53). The same could be the case in Palestine: as care providers get more skilled in using the eRegistry, the time spent on processes of data entry might shorten. Moreover, since it currently is only the client files that have been computerised, it is expected that the time spent on health information management will decrease when reporting is eliminated from care providers' routines.

In line with this, it is important to consider that computer literacy in Palestine might be different from that in high-income contexts. A time-motion study in Ghana and Tanzania, in which healthcare workers were not used to working with computers, was conducted 17 months post-implementation (54). According to the Palestinian Central Bureau of Statistics, there was 53.2 per cent of households in the West Bank that had a computer at home in 2011 (67). This is substantially lower than in the US, where most time-motion studies are from, in which 83.8 per cent of all households had access to a computer at home in 2013 (68). This indicates that it could take Palestinian care providers more time before the system is used as intended. Therefore, studying the impact of the eRegistry on care providers' time allocation might preferably be done after more time has elapsed since the implementation.

The median time that care providers spent on information reporting, here defined as writing in the register and the statistics book, was 0.5 minutes in control and 1.0 minute in the intervention clinics. The difference is not statistically significant, and there is no reason for why this differed between the two groups, since the reporting activities are the same. Considering the time consumption among care providers in intervention clinics, this would indicate that the computerisation of reporting would relieve care providers of 1 minute's work. Based on these results, only small decreases would result from incorporating reporting in the MCH eRegistry. However, it is likely that considerable proportions of time spent on reporting were not observed, as the observers only to a limited extent observed after-consultation time, which is when most of the daily reporting routines take place. It is also worth noting that the time spent on monthly reporting to the MoH was not observed, which will add to the total reporting time that will be eliminated when reporting is automatic. The results on information reporting are therefore likely to underestimate the actual time consumed by these tasks.

Time has been recognised as a central factor in providing high quality of client care (69, 70). Care providers in the intervention clinics spent significantly less time on client care compared

to care providers in the control clinics (median 2.9 and 1.7 minutes in control and intervention). There is valid reason for questioning these results, as it is hard to imagine how the regular list of care-related tasks, such as taking the blood pressure, measuring the weight and performing counselling, which is considered an important component in ANC (60), can be performed in this short amount of time. A large number of the observed consultations did not involve health education and counselling. This diverge substantially from the WHO ANC model (60), which indicate that appropriate health education and counselling should take approximately 15 minutes (50).

This gap might nevertheless have been caused by a failure of the data collection tool to capture care-related activities adequately, especially since it was not able to capture multi-tasking. For example, if care providers counselled a woman at the same time as she wrote down information in the MCH Handbook, this would be stored as information documentation, thus concealing a care-related task. On the other hand, it may be argued that client care is neither adequate nor complete if the care provider does not make eye contact with the clients (71). It is worth noting that we only observed time spent on care-related tasks performed by the nurse or midwife in the main consultation room. In some clinics, doctors, nurses and midwives perform parts of the care-related procedures in a separate examination room. However, this was only to a limited extent reflected in the data, which would suggest that it either did not take place, or the observers failed to record it. It must be emphasised that these results are based on few observations, and in five of the observed consultations, tasks classified as client care were not reported. There is therefore not enough information in the data to draw any conclusions about the intervention clinics spending less time on client care.

An eRegistry seeks to increase the availability and timely use of routine data in order to improve the quality of care and health outcomes (6). Given that the system is able to fill these functions, it might not be inherently negative that care providers that use the MCH eRegistry spend more time on ANC consultations and health information management. After all, the aim is that care providers offer services of high quality according to each woman's needs. The time spent in ANC consultations therefore depends on each client's need and risk profile, which suggests that there is no ideal duration of ANC consultations. If time is saved on unnecessary tasks, such as duplicated data entry, this is clearly a positive outcome of the implementation. However, reductions in time spent on isolated work processes are meaningless unless accompanied with improvements in quality of care.

The rationale is that shortened time consumed by managing redundant health information could have a positive impact on the time available for client care (15). Nevertheless, the MCH eRegistry is still in its early stages of implementation. If the implementation were associated with time savings, it is not clear how this time would be optimally reallocated. Moreover, it is uncertain whether the magnitude of the saved time will be large enough to be detected in its alternative utilisation.

5.1.1 Strengths and limitations

A central limitation of the pilot study was the small and unbalanced sample size that was achieved. This lowered the power of the study to detect differences between the two groups. The substantially higher numbers of consultations in the control clinics compared to the intervention clinics may have been influenced by the information that the selection of clinics was based on. It could have been out-dated, or there may have been unforeseen factors that led to higher numbers of women attending ANC in the control clinics on the days of observation, compared to the intervention clinics.

Another contributing element could have been the total number of observation hours. The observers were instructed to observe the whole workday. However, due to complications related to logistics and travel, observers were not always able to observe the entire day. Some consultations could therefore have been missed, possibly relatively more often in the intervention arm. The workflow in clinics that had a high number of women attending for ANC might have been different from those with fewer clients, since care providers might conduct their tasks in more of a hurry when there are many clients waiting. Thus, the comparability to clinics with fewer attending women might have been weakened.

Moreover, the small and unbalanced sample could have had a negative impact on the amount of missing values in the analysis categories. For example, only one observation from intervention clinics reported an observation of tasks belonging in the miscellaneous category. This could suggest that the task categories aim too widely, or the interpretation of the observed tasks among the observers might be diverging. In either case, the small sample size exacerbates the effect of these two factors. In spite of these limitations, the observations were

valuable for understanding care providers' workflow for informing the calculation of power for the planned time-motion study.

5.2 Methodological considerations

The strengths and limitations of the pilot study pertain to a large extent to the characteristics of the applied methodologies. Therefore, the results will be interpreted through these lenses.

5.2.1 Workflow mapping

In advance of the pilot study, Palestinian care providers' workflow was mapped during field visits in the West Bank. This was necessary for designing a realistic data collection tool, and involved identifying the sequence of tasks for understanding care providers' work process (52). The identified workflow reflects that care providers tend to initiate documentation in the MCH Handbook, and not in the eRegistry, using it more for documentation rather than as a point-of-care tool. Clinical decisions might effectively be made before information is entered into the MCH eRegistry, and as a result, there is a risk that the automatic feedback from the system is disregarded. A potential consequence of the underutilisation of the clinical decision support component could be that the checklist for history taking and health education is left partly or entirely unutilised. This might lead to substandard quality of care, with the risk of untimely management of critical conditions leading to adverse pregnancy outcomes. Moreover, the system is designed to offer standardised care to meet the needs of all women, regardless of age, education level, income level and place of residence. If the checklists are not followed as intended, equitable care provision might be at stake.

A limitation with the workflow mapping was that we failed to understand the extent to which other MCH-related consultations, such as postnatal care and family planning, took place on the same days as ANC. Care providers having to perform different types of services was likely to have impacted their workflow. Furthermore, it most probably affected the number of ANC consultations that were observed. Family planning and postnatal care consultations were observed, but were excluded from the analysis

5.2.2 Sampling and sample size

The workflow exercise was conducted in six clinics that were selected by purposive sampling. With this technique, the sample is non-randomly selected based on a specific

purpose. For the workflow mapping, the purpose was to understand the workflow in Palestinian PHC with and without the MCH eRegistry. Since it is not random, its representativeness is weak. Indeed, the sample was confined to two governorates. The exercise should ideally have been conducted in a larger number of clinics to get a more complete picture of the workflow in Palestinian PHC. If more clinics had been observed, more of the variability between clinics and care providers would probably have been captured. Nevertheless, the sampling procedure was deemed satisfactory for the objective of the workflow mapping exercise, namely to achieve an understanding of the workflow with the purpose of identifying and developing realistic task categories for the data collection tool.

The six clinics that were observed for the pilot study observations were similarly selected by means of purposive sampling. The geographical spread was limited to two governorates only, which indicates that its representativeness is questionable. This is a clear limitation with this sampling technique. On the other hand, it allowed for selecting clinics that both met the eligibility criteria and were located within a practically feasible distance given the available resources for the conduct of the pilot study. The intention of the sample selection was to achieve comparability between the care providers' time allocation in clinics in the control group and clinics in the intervention group. As such, only mid-size clinics that would have a reasonably balanced number of observations would be included, in addition to clinics having only one MCH nurse or midwife. The selection of clinics that matched these criteria was based on averages from historical records. The expected number of observed consultations was therefore uncertain, even more so because booking visits were not prescheduled.

5.2.3 Data collection tool

The Microsoft Access tool that was used in the pilot study allowed measurements to the closest second, thus achieving accurate time data. The ideal data collection tool would have task categories that were detailed enough to capture all the observed activities, leaving no room for misinterpretation. However, there will always be a trade-off between having tasks covering “everything” on the one hand, and accounting for the observers' cognitive ability to process and accurately record the observed activities on the other. Striking a balance between the level of detail and maintaining a manageable amount of tasks is therefore a challenge in developing an appropriate data collection tool.

In order to develop a realistic tool, feedback from PNIPH staff and the observers was crucial. The final version used for the observations was therefore largely developed in communication with the observers. Also after the conduct of the observations, minor adjustments were made to the tool based on their feedback and comments. The observers suggested that the task categories were left as they were.

Nevertheless, a challenge that was raised by the observers was that the tool was not able to “track” women in a satisfactory manner. This would be relevant in cases in which women left the consultation room and came back after having been to the lab or the doctor’s room, while the nurse in the meantime would see other clients for consultation. Retrieving the observation number of a woman who re-enters the room was an identified difficulty. The tool does allow for continuing a closed observation, but observations are only linked to an observation number, which implied that the observer would have to remember which number her observation was stored as, which might be challenging in situations with considerable amounts of attending women.

Another limitation with the data collection tool was that it was unable to record more than one task at the time. This might have compromised the ability of the tool to accurately capture the tasks performed by the care providers. Even if the observers were trained in which tasks to select in case of multitasking, the complexity of the work activities might have been concealed. However, for the main outcome of the study, this was not considered a major concern, precisely because the observers were trained to let the physical activity determine what the tasks should be recorded as. However, the frequency of information management-related tasks could be overstated and skew the results towards an interpretation of a larger contribution of these tasks than was actually the case. In spite of this obvious limitation, the data collection tool was still able to capture the difference in time consumed by health information tasks between the intervention and control clinics, which after all was the primary objective of the study. As such, it accommodated the needs of the study in a satisfactory manner.

5.2.4 Time-motion method

An advantage with the time-motion methodology is its ability to produce accurate results with second’s precision, given a data collection tool that allows for this (15), such as the one

used for this study. It is particularly suitable in work settings in which the study subject's workflow is fragmented and the time it takes to perform specific tasks is short (17, 53). Compared to the work sampling technique, which collects data on the activities performed at fixed intervals of time (48), the time-motion method is in principle able to capture all activities performed and does so more precisely, since it captures both the frequency and the duration of tasks. As such, it may provide a more complete picture of work contexts than the work sampling method is able to. However, a challenge identified during the workflow mapping was that it seems to be more common than expected that care providers work in pairs or split the tasks between them. This complicates the use of the time-motion technique, since it requires a one-on-one subject-observer ratio (48). Observing only one of the care providers when there are two or more would complicate the observations, and even if the observer were able to focus on only one care provider, the comparability across observations would be compromised. The conduct of time-motion studies therefore tends to be costly and time-consuming, which often results in small sample sizes (14, 48).

The work sampling technique allows for one observer studying multiple subjects (15), suggesting that work sampling could be a potential alternative. Work sampling would nevertheless require a considerably larger number of observations in order to achieve representativeness of the studied work process. This indicates that work sampling does a better job in studying more standardised work processes than is the case in ANC in Palestinian PHC. Another alternative to time-motion studies is time efficiency questionnaires, which involve care providers themselves recording and reporting the time allocated to various work tasks. This method is considerably more prone to bias compared to the time-motion method (72).

Some time-motion studies report the outcome measure as proportion of time (49, 56), while for this study; the primary outcome is reported as absolute time. In the context of ANC, the total length of a consultation visit may vary according to factors such as the woman's risk profile, the woman's education level (e.g. if she needs more counselling than the average client), and the care provider's workflow. Therefore, the proportion of health information management would vary substantially as it is sensitive to the relative contribution of other tasks to the total amount of time. Little is known about the effects on time of electronic health information systems, making proportions tricky measures to interpret. As such, absolute time is a less variable measure, although it might still be of interest to consider the differences in

proportion. For example, the study observations proved that the difference in the proportion of health information management time between the intervention and control group is rather small, while the absolute difference seems quite large.

While the primary outcome for the pilot study was time spent on health information management, it could be argued that such a singular focus on one specific aspect of the work process might be misleading. It has been upheld that studies that reduce the impact of a tool to only one out of many work processes that constitute the delivery of healthcare, might underestimate or conceal benefits and disadvantages experienced in other areas of the work processes (15). Due to the methodological focus on individual study subjects in time-motion studies, the holistic perspective and the impact that eHealth tools have on the various work processes involved in healthcare delivery is neglected (15). It has been recommended that time efficiency should be interpreted in terms of the institution's or the health system's efficiency, rather than solely on the user's efficiency (15). After all, it is the ability to provide high quality of care that is the ultimate goal of the implementation of such a system.

An apparent limitation of the time-motion methodology is that it is impossible to eliminate the risk of study subjects behaving differently because they know they are being observed. This is known as the "Hawthorne effect" (73). Nevertheless, this effect is likely to be mitigated if observers avoid interfering to the largest extent possible. This was emphasised during the training of the observers.

Similarly, it is impossible to entirely eliminate diverging subjective interpretations of the observed tasks. Calibrating for inter-observer reliability, which aims to maximise the agreement between observers, is likely to reduce this bias (74). This was not performed for the pilot study. Inter-observer reliability is not always accounted for in the published time-motion literature, and there is no standardised method to calibrate inter-observer disagreement across studies (14). Nonetheless, observers with similar professional backgrounds and skills in the observed clinical context are likely to minimise the risk of deviating interpretations of the observed tasks. For the pilot study, observers had to be familiar with the workflow of MCH care providers to be able to identify all the tasks performed in an ANC setting. Since ANC consultations are exclusively with women, it was crucial that observers were female.

Rigorous training in advance of the observations is vital in order to achieve agreement between observers. In spite of the training that was given to the observers, it was experienced that the observers needed reinforcement along the conduct of the observations, which suggests that training should have been fortified and the training manual should have been further explored. Blinding the observers to the study's outcomes of interest could reduce the potential for bias. In the pilot study, the observers were familiar with the project and were as such not masked to the study's outcomes. Nevertheless, the possibility that tasks might be misclassified and subjectively interpreted is inherent to observational studies, and cannot be entirely eliminated. With considerable risk of bias, triangulation of the results would have increased the robustness of the results (16), for example by means of staff surveys (17, 53). This was not conducted for the pilot study.

The study involved several observations of the same care provider, which caused a lack of independence between the observations. It would therefore be necessary to estimate the correlation between clients "within" each care provider (17). This was, however, not controlled for in the pilot study. If this had been included, the power of the tests is likely to have been weakened.

The lessons learnt from the pilot study are beneficial for the design of the time-motion study. It pointed at weaknesses with the implementation of the MCH eRegistry, and the identified limitations would inform the optimisation of how training and observations should be carried out. This therefore reinforces the importance and value of conducting a pilot in advance of a full-scale time-motion study.

6 Implications and recommendations

This section will employ the implications of the conducted background work and the results of the pilot study in providing recommendations for the conduct of the planned time-motion study.

6.1 Workflow

The workflow that was identified in the visited clinics suggests that the MCH eRegistry is not realising its full potential. The recommended workflow of care providers using the MCH eRegistry will therefore be presented.

Compared to the description of the identified workflow in clinics with the MCH eRegistry (Figure 2), there are two points in the work process that should be changed in order for the MCH eRegistry to reach its full potential (Figure 5). First, the MCH eRegistry should be used for primary data entry. This is in line with the intention of the tool, namely to alert the care provider if any abnormal values are entered into the MCH eRegistry. For example, if the care provider enters a haemoglobin value that is beyond the normal range, the eRegistry will immediately generate an alert that prompts action from the care provider. Other documentation, such as writing in the MCH Handbook and ordering lab tests, follows subsequently. Second, since it was found that reporting was not yet integrated into the MCH eRegistry, and that reporting was still conducted on paper, the workflow demonstrated below (Figure 5) excludes the use of the register and statistics book. As such, care providers would be able to fully exploit the benefits of the system.

How workflow will change when reporting is incorporated in the MCH eRegistry is unclear, but there is reason to believe that, at a minimum, it will relieve the care providers from parts of the health information management workload. The planned time-motion study will be conducted after reporting has been computerised. These results will not only provide evidence about the time spent on different tasks: they will also inform about the care providers' use of the MCH eRegistry and indicate whether they use the system as intended.

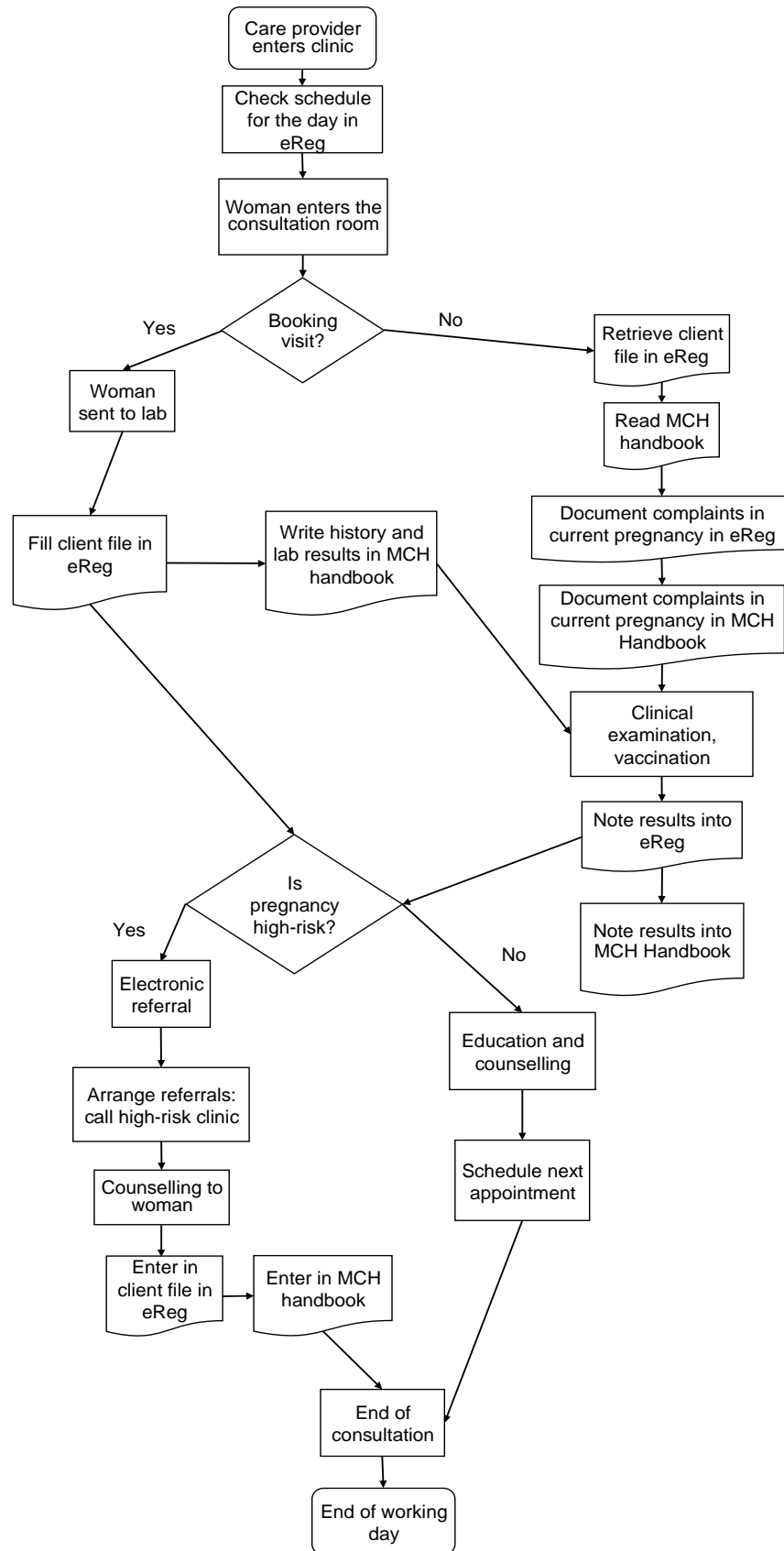


Figure 5: Anticipated workflow after the introduction of the MCH eRegistry. Workflow process chart adapted from ASQ (63).

6.2 Data collection tool

Based on the experiences and issues raised after the conduct of the observations in the pilot study, suggestions accommodating the raised concerns will be proposed.

As mentioned, MCH-related services other than ANC, such as family planning and postnatal care, took place in the observed clinics more often than expected. The observers found the tool inadequate in capturing what kind of visit that was being observed. It is therefore suggested that a function capturing this should be added to the tool's opening screen (Figure 6). The observer would be able to, for each new observation, choose the type of visit. This is likely to improve consistency across the observers, and the type of service that is offered would be clear for the data analyst.

The screenshot shows a web form titled "Observation Info". It contains the following fields and controls:

- Observation #:** A text input field containing the number "27".
- Date:** A date input field containing "28.05.2017".
- Type of visit:** A dropdown menu with a downward arrow.
- Observation Type:** A list box containing three options: "Postnatal Care", "Family Planning", and "ANC". The "ANC" option is currently selected and highlighted.
- Patients Observed:** A text input field containing "Total Patients Seen".
- Comment:** A large, empty text area for entering notes.
- Observer:** A dropdown menu with a downward arrow.
- Buttons:** Two buttons at the bottom: "OPEN Entry Form" and "SAVE / CLOSE".

Figure 6:
Screenshot of modifications made to the data collection tool: added possibility to choose the type of visit (ANC, family planning or postnatal care).

Similarly, distinguishing between booking and follow-up visits was not straightforwardly captured in the tool. This issue complicated the analysis, and might have led to fewer consultations identified as booking visits in the data than were actually the case. As a response to this, it is suggested that a similar function as the one above is added to the tool, which indicates the type of observation. This would make it easier to record whether the consultation was a booking or a follow-up visit, in addition to facilitate the analysis of the data.

The screenshot shows a web form titled "Observation Info". It contains the following fields and controls:

- Observation #:** A text input field containing the number "27".
- Date:** A date input field containing "28.05.2017".
- Type of visit:** A dropdown menu with "ANC" selected.
- Observation Type:** A dropdown menu with "Booking visit" selected.
- Sessions:** A checkbox that is currently unchecked.
- Patients Observed:** A dropdown menu with "Follow-up visit" selected.
- Patients Seen:** A checkbox that is currently unchecked.
- Comment:** A large text area for entering notes.
- Observer:** A dropdown menu for selecting the observer.

At the bottom of the form, there are two buttons: "OPEN Entry Form" and "SAVE / CLOSE".

Figure 7:
Screenshot of modifications made to the data collection tool: added possibility to choose whether the ANC visit is a booking or a follow-up visit.

The observers experienced certain difficulties in ensuring that the data collection tool kept track of the clients in case they left the main consultation room and came back after the care provider had seen another woman. For the planned time-motion study, it is suggested that the care providers write a number for each woman in the register book that the observers could look at in order to retrieve the correct observation.

Lastly, as mentioned, the data collection tool was not able to store more than one task at the time. Nevertheless, data collection tools that allow for multitasking do exist. One example is the “Time Capture Tool”, also called “TimeCaT” (75). This is an open, web-based application that allows for multitasking, assesses inter-observer reliability and claims to provide facilitated data analysis. However, the existing version of TimeCaT did not work without an Internet connection (75), which left it unfeasible for the pilot study, as there was no Internet connection in the control clinics. It is expected that the TimeCaT tool will be updated to allow for off-line use, which would make it a viable alternative data collection tool for the up-coming time-motion study.

6.3 Time-motion study implications

The pilot study has identified strong and weak points that must be addressed in the design of the time-motion trial. Recommendations will therefore be suggested for the optimal conduct of the study.

First, it is estimated that a sample size of 120 observations must be achieved in order to achieve a study powered to detect a minimum difference of 3 minutes ($\alpha = 0.05$, power: 80 per cent). The purpose of the power calculations was to estimate the optimal allocation of resources. A weakly powered study with a small sample size would be unable to detect important effects, while a study with a sample size that is too large would not add any benefit to the study, and wastes time and resources (76). For the time-motion study, in spite of the estimated sample size, it is likely that the size will be limited by the 83 clinics that are eligible. Additionally, logistics challenges might further reduce the number of clinics that are practically feasible to observe. It is therefore not certain whether the desirable size of the samples will be achieved. These issues must be taken into account for the design of the time-motion study.

Second, as pointed to above, the design of time-motion studies is such that multiple observations are performed on the same individuals, which means that the observations might not be independent. For the time-motion study, the intra-cluster correlation coefficient should be calculated (74).

Third, the importance and value of performing rigorous training were clearly demonstrated during the observations for the pilot study, especially in terms of minimising the risk of observer bias. This emphasises the importance of using external observers that are not familiar with the study outcomes and objectives. Inter-observer reliability should therefore be addressed during training. The person conducting the training should thoroughly present the data collection tool, together with the different tasks in the entry screen and how they are to be interpreted. The observers should practice in using the tool by watching the training videos made during the field visits, and take the time of the different activities they observe. Following this, test observations on non-study care providers should be conducted in order to test the validity between the observers. The results of these validity tests should then be compared and the main sources of variability should be identified. A discussion concerning how and why this variability arose should take place. Lastly, a consensus on a “gold-standard” interpretation of the activities should be established between the observers.

7 Conclusions

This thesis has described the design and development of a time-motion study that will investigate the MCH eRegistry's potential for time efficiency in the context of ANC in Palestine. It has demonstrated the opportunities that lie in evaluating the impact of an electronic health information tool in a middle-income country.

The conduct of the pilot study proved that the developed data collection tool was satisfactory for the study's objective of conducting time-motion style observations in a context of ANC, although with certain drawbacks. Based on the results of the observations, there were no significant differences in the time spent on health information management between clinics with and without the MCH eRegistry. Consistent with other studies (17, 53, 54), the most important message is that time is not added when an electronic health information system is introduced. Care providers may therefore benefit from the system's advantages without increasing their workload.

The estimations of sample size for the future time-motion study showed that the sample size of 120 clinics that is required to have the statistical power to detect a difference between the two study arms was considerably larger than the 83 clinics that are eligible. This implies that there might be a trade-off between achieving statistical power, and a study design that is practically feasible, given the exclusion criteria of the study.

The thesis has resulted in valuable lessons for the conduct of a time-motion study. First, the importance of thoroughly mapping the workflow in order to develop an appropriate data collection tool has been demonstrated, and second, the significance of conducting rigorous training in advance of the time-motion observations has been emphasised. It has provided a transparent research design that can be replicated to similar middle-income contexts, at the same time as the significance of context-specific adaptation has been highlighted.

The MCH eRegistry in Palestine is currently sub-optimally integrated into care providers' work routines due to the delays in automated reporting and transition to new work routines. The system needs to be fully matured before a meaningful efficiency assessment can take place.

References

1. Flenady V, Wojcieszek AM, Fjeldheim I, Friberg IK, Nankabirwa V, Jani JV, et al. eRegistries: indicators for the WHO Essential Interventions for reproductive, maternal, newborn and child health. *BMC Pregnancy and Childbirth*. 2016;16(1):293.
2. World Health Organization. Health in 2015: From MDGs, Millennium Development Goals to SDGs. Sustainable Development Goals. 2015:17.
3. United Nations: The Millennium Development Goals Report 2015. New York: The United Nations; 2015.
4. Azubuike MC, Ehiri JE. Health information systems in developing countries: benefits, problems, and prospects. *The Journal of the Royal Society for the Promotion of Health*. 1999;119(3):180-4.
5. Lippeveld T. Routine data collection methods. In: Lippeveld T, Sauerborn, R., Bodart, C., editor. *Design and Implementation of Health Information Systems*. Geneva: World Health Organization; 2000.
6. Frøen JF, Myhre SL, Frost MJ, Chou D, Mehl G, Say L, et al. eRegistries: Electronic registries for maternal and child health. *BMC pregnancy and childbirth*. 2016;16(1):11.
7. eRegistries Initiative: What are eRegistries? Oslo, Norway 2017 [Available from: <http://new.eregistries.org/-aboutus>].
8. PCBS. Palestinians at the End of 2015: PCBS; 2015 [Available from: <http://www.pcbs.gov.ps/site/512/default.aspx?tabID=512&lang=en&ItemID=1566&mid=3171&wversion=Staging>].
9. Giacaman R, Khatib R, Shabaneh L, Ramlawi A, Sabri B, Sabatinelli G, et al. Health status and health services in the occupied Palestinian territory. *The Lancet*. 2009;373(9666):837-49.
10. Palestinian Central Bureau of Statistics. Palestine in Figures 2015. Ramallah, Palestine: PCBS; 2016 March, 2016.
11. Palestinian Ministry of Health: Health Annual Report Palestine 2015. Nablus, Palestine: Palestinian Health Information Center, MoH; 2016.
12. World Health Organization, Regional Office for the Eastern Mediterranean: Palestine health profile 2015. Cairo: World Health Organization, EMRO; 2016.
13. ISRCTN Registry: An electronic health registry with interactive checklists and clinical decision support for improving quality of antenatal care: BioMed Central; [Available from: <http://www.isrctn.com/ISRCTN18008445?q=eRegistries&filters=&sort=&offset=1&totalResults=1&page=1&pageSize=10&searchType=basic-search>].

14. Zheng K, Guo MH, Hanauer DA. Using the time and motion method to study clinical work processes and workflow: methodological inconsistencies and a call for standardized research. *Journal of the American Medical Informatics Association*. 2011;18(5):704-10.
15. Poissant L, Pereira J, Tamblyn R, Kawasumi Y. The impact of electronic health records on time efficiency of physicians and nurses: a systematic review. *Journal of the American Medical Informatics Association*. 2005;12(5):505-16.
16. Unertl KM, Novak LL, Johnson KB, Lorenzi NM. Traversing the many paths of workflow research: developing a conceptual framework of workflow terminology through a systematic literature review. *Journal of the American Medical Informatics Association*. 2010;17(3):265-73.
17. Pizziferri L, Kittler AF, Volk LA, Honour MM, Gupta S, Wang S, et al. Primary care physician time utilization before and after implementation of an electronic health record: a time-motion study. *Journal of Biomedical Informatics*. 2005;38(3):176-88.
18. Alkema L, Chou D, Hogan D, Zhang S, Moller A-B, Gemmill A, et al. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *The Lancet*. 2016;387(10017):462-74.
19. Ritchie LMP, Khan S, Moore JE, Timmings C, van Lettow M, Vogel JP, et al. Low- and middle-income countries face many common barriers to implementation of maternal health evidence products. *Journal of Clinical Epidemiology*. 2016;76:229-37.
20. Byass P. The unequal world of health data. *PLoS Med*. 2009;6(11).
21. Hodgins S, D'Agostino A. The quality–coverage gap in antenatal care: toward better measurement of effective coverage. *Global Health: Science and Practice*. 2014;2(2):173-81.
22. Sauerborn R, Lippeveld, T. Introduction. In: Lippeveld T, Sauerborn, R., Bodart, C., editor. *Design and implementation of health information systems*. Geneva: World Health Organization; 2000.
23. AbouZahr C, Boerma T. Health information systems: the foundations of public health. *Bulletin of the World Health Organization*. 2005;83(8):578-83.
24. MEASURE Evaluation. *Routine Health Information Systems*. In: MEASURE Evaluation, editor. Chapel Hill: Carolina Population Center, University of North Carolina; 2016.
25. Mimi Y. *The Routine Health Information System in Palestine: Determinants and Performance [dissertation]*. City University London; 2015.
26. Sauerborn R. Nonroutine data collection methods: an overview. In: Lippeveld T, Sauerborn, R., Bodart, C., editor. *Design and Implementation of Health Information Systems*. Geneva: World Health Organization; 2000.
27. The DHS Program: DHS Overview: Demographic and Health Survey (DHS) Program; 2017 [Available from: <http://dhsprogram.com/What-We-Do/Survey-Types/DHS.cfm>].

28. Krickeberg K. Principles of health information systems in developing countries. *Health Information Management Journal*. 2007;36(3):8-20.
29. Lippeveld T, Sauerborn, R. A framework for designing health information systems. In: Lippeveld T, Sauerborn, R., Bodart, C., editor. *Design and implementation of health information systems*. Geneva: World Health Organization; 2000.
30. Stansfield SK, Walsh J, Prata N, Evans T, Jamison D, Breman J, et al. Information to improve decision making for health. *Disease control priorities in developing countries*. 2006;2:1017-30.
31. MA4Health. *The Roadmap for Health Measurement and Accountability*. Washington, D.C.: USAID, World Bank, WHO; 2015.
32. Cairncross S, Peries H, Cutts F. Vertical health programmes. *The Lancet*. 1997:S20.
33. Hendrich A, Chow M, Skierczynski BA, Lu Z. A 36-hospital time and motion study: How do medical-surgical nurses spend their time? RCHE Publications. 2008:50.
34. Institute of Medicine: *Crossing the quality chasm: A new health system for the 21st century*. Washington DC: National Academy Press; 2001. 1192 p.
35. Sapirie S. Foreword. In: Lippeveld T, Sauerborn, R., Bodart, C. , editor. *Design and implementation of health information systems*. Geneva: World Health Organization; 2000.
36. WHO. *World Health Assembly Resolution 58.28: eHealth*. Geneva: World Health Organization; 2005.
37. Gerber T, Olazabal V, Brown K, Pablos-Mendez A. An agenda for action on global e-health. *Health Affairs*. 2010;29(2):233-6.
38. Wilson K, Gertz B, Arenth B, Salisbury N. *The journey to scale: moving together past digital health pilots*. Seattle: PATH. 2014.
39. Piette JD, Lun K, Moura Jr LA, Fraser HS, Mechael PN, Powell J, et al. Impacts of e-health on the outcomes of care in low-and middle-income countries: where do we go from here? *Bulletin of the World Health Organization*. 2012;90(5):365-72.
40. Kiberu VM, Matovu JK, Makumbi F, Kyoziira C, Mukooyo E, Wanyenze RK. Strengthening district-based health reporting through the district health management information software system: the Ugandan experience. *BMC Medical Informatics and Decision Making*. 2014;14(1):40.
41. Gera R, Muthusamy N, Bahulekar A, Sharma A, Singh P, Sekhar A, et al. An in-depth assessment of India's Mother and Child Tracking System (MCTS) in Rajasthan and Uttar Pradesh. *BMC health services research*. 2015;15(1):315.
42. (HISP) HISP. *DHIS2 tracker e-Registry in Palestine 2016* [Available from: https://docs.dhis2.org/master/en/user-stories/html/user_story_palestine_tracker.html].
43. Schoenbaum M, Afifi AK, Deckelbaum RJ. *Strengthening the Palestinian health system*: Rand Corporation; 2005.

44. Rahim HFA, Wick L, Halileh S, Hassan-Bitar S, Chekir H, Watt G, et al. Maternal and child health in the occupied Palestinian territory. *The Lancet*. 2009;373(9667):967-77.
45. Mataria A, Khatib R, Donaldson C, Bossert T, Hunter DJ, Alsayed F, et al. The health-care system: an assessment and reform agenda. *The Lancet*. 2009;373(9670):1207-17.
46. PNIPH. Harmonized Reproductive Health e-Registry Ramallah: Palestinian National Institute of Public Health; 2016 [Available from: <http://pniph.org/site/article/27>].
47. Lopetegui M, Yen P-Y, Lai A, Jeffries J, Embi P, Payne P. Time motion studies in healthcare: what are we talking about? *Journal of Biomedical Informatics*. 2014;49:292-9.
48. Finkler SA, Knickman JR, Hendrickson G, Lipkin Jr M, Thompson WG. A comparison of work-sampling and time-and-motion techniques for studies in health services research. *Health Services Research*. 1993;28(5):577.
49. Were M, Sutherland J, Bwana M, Ssali J, Emenyonu N, Tierney W. Patterns of care in two HIV continuity clinics in Uganda, Africa: a time-motion study. *AIDS care*. 2008;20(6):677-82.
50. von Both C, Fleßa S, Makuwani A, Mpembeni R, Jahn A. How much time do health services spend on antenatal care? Implications for the introduction of the focused antenatal care model in Tanzania. *BMC Pregnancy and Childbirth*. 2006;6(1):22.
51. Agency for Healthcare Research and Quality: Time and Motion Studies Database U.S. Department of Health & Human Services; [cited 2017 18.02.2017]. [Available from: <https://healthit.ahrq.gov/health-it-tools-and-resources/time-and-motion-studies-database>].
52. Deelman E, Gannon D, Shields M, Taylor I. Workflows and e-Science: An overview of workflow system features and capabilities. *Future Generation Computer Systems*. 2009;25(5):528-40.
53. Overhage JM, Perkins S, Tierney WM, McDonald CJ. Controlled trial of direct physician order entry: effects on physicians' time utilization in ambulatory primary care internal medicine practices. *Journal of the American Medical Informatics Association*. 2001;8(4):361-71.
54. Mensah N, Sukums F, Awine T, Meid A, Williams J, Akweongo P, et al. Impact of an electronic clinical decision support system on workflow in antenatal care: the QUALMAT eCDSS in rural health care facilities in Ghana and Tanzania. *Global Health Action*. 2015;8.
55. Lo HG, Newmark LP, Yoon C, Volk LA, Carlson VL, Kittler AF, et al. Electronic health records in specialty care: a time-motion study. *Journal of the American Medical Informatics Association*. 2007;14(5):609-15.
56. Were MC, Shen C, Bwana M, Emenyonu N, Musinguzi N, Nkuyahaga F, et al. Creation and evaluation of EMR-based paper clinical summaries to support HIV-care in Uganda, Africa. *International Journal of Medical Informatics*. 2010;79(2):90-6.
57. Mangham-Jefferies L, Mathewos B, Russell J, Bekele A. How do health extension workers in Ethiopia allocate their time? *Human Resources for Health*. 2014;12(1):61.

58. Rotich JK, Hannan TJ, Smith FE, Bii J, Odero WW, Vu N, et al. Installing and implementing a computer-based patient record system in sub-Saharan Africa: the Mosoriot Medical Record System. *Journal of the American Medical Informatics Association*. 2003;10(4):295-303.
59. Wick L, Mikki N, Giacaman R, Abdul - Rahim H. Childbirth in palestine. *International Journal of Gynecology & Obstetrics*. 2005;89(2):174-8.
60. WHO. WHO antenatal care randomized trial: manual for the implementation of the new model. Geneva: World Health Organization. 2002;37.
61. Teddlie C, Yu F. Mixed methods sampling: A typology with examples. *Journal of Mixed Methods Research*. 2007;1(1):77-100.
62. Willis K. Interviewing. In: Desai VaP, R. B., editor. *Doing Development Research*. London, United Kingdom: Sage; 2006 p. 144-52.
63. ASQ. What is a Process Flowchart? ASQ: Learn About Quality2017 [Available from: <http://asq.org/learn-about-quality/process-analysis-tools/overview/flowchart.html>].
64. Tang Z, Weavind L, Mazabob J, Thomas EJ, Chu-Weininger MYL, Johnson TR. Workflow in intensive care unit remote monitoring: a time-and-motion study. *Critical Care Medicine*. 2007;35(9):2057-63.
65. Newbold P, Carlson W, Thorne B. *Statistics for business and economics*. 8th ed. Essex: Pearson; 2012.
66. Shu K, Boyle D, Spurr C, Horsky J, Heiman H, O Connor P, et al. Comparison of time spent writing orders on paper with computerized physician order entry. *Studies in Health Technology and Informatics*. 2001(2):1207-11.
67. Palestinian Central Bureau of Statistics. *Household Survey on Information and Communications Technology*. Ramallah: PCBS; 2011.
68. Access to computers from home (indicator) [Internet]. 2017 [cited 15.06.2017]. Available from: <https://data.oecd.org/ict/access-to-computers-from-home.htm>.
69. Chen LM, Farwell WR, Jha AK. Primary care visit duration and quality: does good care take longer? *Archives of Internal Medicine*. 2009;169(20):1866-72.
70. Howie J, Porter A, Heaney D, Hopton J. Long to short consultation ratio: a proxy measure of quality of care for general practice. *Br J Gen Pract*. 1991;41(343):48-54.
71. Montague E, Asan O. Dynamic modeling of patient and physician eye gaze to understand the effects of electronic health records on doctor-patient communication and attention. *International Journal of Medical Informatics*. 2014;83(3):225-34.
72. Burke TA, McKee JR, Wilson HC, Donahue RM, Batenhorst AS, Pathak DS. A comparison of time-and-motion and self-reporting methods of work measurement. *Journal of Nursing Administration*. 2000;30(3):118-25.

73. Franke RH, Kaul JD. The Hawthorne experiments: first statistical interpretation. *American Sociological Review*. 1978:623-43.
74. Lopetegui MA, Bai S, Yen P-Y, Lai A, Embi P, Payne PR, editors. Inter-observer reliability assessments in time motion studies: the foundation for meaningful clinical workflow analysis. *AMIA Annual Symposium Proceedings*; 2013: American Medical Informatics Association.
75. Lopetegui M, Yen P-Y, Lai AM, Embi PJ, Payne PR, editors. Time Capture Tool (TimeCaT): development of a comprehensive application to support data capture for Time Motion Studies. *AMIA Annual Symposium Proceedings*; 2012: American Medical Informatics Association.
76. StataCorp. 2013. *Stata: Release 13. Statistical Software*. College Station, TX: StataCorp LP.

Appendices

A. Ethical clearance documents

1. Palestinian Health Research Council

7



المجلس الفلسطيني للبحوث الصحي Palestinian Health Research Council

تعزيز النظام الصحي الفلسطيني من خلال مأسسة استخدام المعلومات البحثية في صنع القرار

Developing the Palestinian health system through institutionalizing the use of information in decision making

Helsinki Committee For Ethical Approval

Date: 2017/04/03

Number: PHRC/HC/208/17

Name: Jahn Frederik Frøen

الاسم:

We would like to inform you that the committee had discussed the proposal of your study about:

نفيدكم علماً بأن اللجنة قد ناقشت مقترح دراستكم حول:

eRegTime: An electronic Maternal and Child Health registry with interactive checklists and clinical decision support for improving efficiency of antenatal care in Palestine – protocol for a sub-study in a cluster randomized trial

The committee has decided to approve the above mentioned research. Approval number PHRC/HC/208/17 in its meeting on 2017/04/03

و قد قررت الموافقة على البحث المذكور عاليه بالرقم والتاريخ المذكوران عاليه

Signature

Member

Member

Chairman



General Conditions:-

1. Valid for 2 years from the date of approval.
2. It is necessary to notify the committee of any change in the approved study protocol.
3. The committee appreciates receiving a copy of your final research when completed.

Specific Conditions:-

E-Mail: pal.phrc@gmail.com

Gaza - Palestine

غزة - فلسطين
شارع النصر - مفترق العيون

2. Regional Committees for Medical and Health Research Ethics in Norway



Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK sør-øst	Claus Henning Thorsen	22845515	19.04.2017	2017/400/REK sør-øst C
			Deres dato:	Deres referanse:
			14.02.2017	

Vår referanse må oppgis ved alle henvendelser

Frederik Frøen
Folkehelseinstituttet

2017/400 Tidseffektivitet av helseinformasjonsteknologier i Palestina

Vi viser til søknad om forhåndsgodkjenning av ovennevnte forskningsprosjekt. Søknaden ble behandlet av Regional komité for medisinsk og helsefaglig forskningsetikk (REK sør-øst) i møtet 23.03.2017. Vurderingen er gjort med hjemmel i helseforskningsloven § 10, jf. forskningsetikkloven § 4.

Forskningsansvarlig: Folkehelseinstituttet
Prosjektleder: Frederik Frøen

Prosjektomtale (original):

This is an intervention study to assess whether a Maternal and Child Health (MCH) eRegistry with interactive checklists and decision support can reduce the times spent for documentation and reporting in Primary Healthcare Clinics offering antenatal care in the West Bank of Palestine. The time-motion method will be applied to assess the time efficiency of the MCH eRegistry versus the paper-based system. Through the time-motion observations, both antenatal care booking and follow-up visits will be observed.

Vurdering

Helseforskningsloven gjelder for medisinsk og helsefaglig forskning, det vil si «virksomhet som utføres med vitenskapelig metodikk for å skaffe til veie ny kunnskap om helse og sykdom», jf. helseforskningsloven § 2, jf. § 4.

Komiteen viser til at prosjektets formål er å sammenligne to måter å innhente og lagre helseinformasjon på, nemlig på papir eller via et interaktivt elektronisk-registreringssystem. Fra protokollen gjengis: "The primary outcome is average time consumption on the health information system per care provider per client". Komiteen mener, basert på den fremlagte dokumentasjon, at studien således ikke har til formål å skaffe til veie ny kunnskap om helse og sykdom, slik dette forstås i helseforskningsloven § 4.

Prosjektet kan gjennomføres uten godkjenning av REK innenfor de ordinære ordninger for helsetjenesten med hensyn til for eksempel regler for taushetsplikt og personvern. Søker bør derfor ta kontakt med enten forskerstøtteavdeling eller personvernombud for å avklare hvilke retningslinjer som er gjeldende.

Vedtak

Etter søknaden fremstår prosjektet ikke som medisinsk og helsefaglig forskning, og det faller derfor utenfor helseforskningslovens virkeområde, jf. helseforskningsloven § 2.

Komiteens avgjørelse var enstemmig.

Besøksadresse:
Gullhaugveien 1-3, 0484 Oslo

Telefon: 22845511
E-post: post@helseforskning.etikkom.no
Web: http://helseforskning.etikkom.no/

All post og e-post som inngår i saksbehandlingen, bes adressert til REK sør-øst og ikke til enkelte personer

Kindly address all mail and e-mails to the Regional Ethics Committee, REK sør-øst, not to individual staff

Komiteens vedtak kan påklages til Den nasjonale forskningsetiske komite for medisin og helsefag, jfr. helseforskningsloven § 10, tredje ledd og forvaltningsloven § 28. En eventuell klage sendes til REK sør-øst C. Klagefristen er tre uker fra mottak av dette brevet, jfr. forvaltningsloven § 29

Med vennlig hilsen

Britt-Ingjerd Nesheim
Professor dr.med
leder REK sør-øst C

Claus Henning Thorsen
Rådgiver

Kopi til: frederik.froen@fhi.no, Nasjonalt folkehelseinstitutt ved øverste administrative ledelse:
reksoknad@fhi.no

B. Training manual for observers

Introduction

This study is a so-called time-motion study, in which we want to know how much time care providers spend on performing different activities, and compare the time spent in the clinics that use the eRegistry versus those who still use paper. The observers' role will be to take the time on all the various tasks that care providers do during an antenatal care workday in primary healthcare clinics. We have developed a data collection tool in the software Microsoft Access. The tool contains a list of activities, and the observer is supposed to click on the corresponding button according to the activity she observes. The time will then automatically be stored in a database linked to the data entry form, which then can be used for analysis. The tool template has been downloaded from the Agency for Healthcare Research and Quality's website: <https://healthit.ahrq.gov/health-it-tools-and-resources/time-and-motion-studies-database> (under "Resources for Time and Motion Studies"). It has further been adjusted to our setting.

Training

Training will take place over two days, and the following points will be covered:

Day 1:

- Introduction to study and methods
- Outline of work flow in clinics
- Introduction to data collection tool
- Training of different data points on tool
- Testing data collection tool hands-on

Day 2:

- Hands-on data collection training with videos
- Testing for inter-rater reliability with videos (whether observers make approximately similar time measurements)
- Feedback on the tool
- Discussions about schedule and timelines
- Informed consent from women – training
- Signing confidentiality agreement

The observers will use laptops with Microsoft Access installed on it. During the observations, the observers will sit on a chair in the consultation room. It is important that the observer is sitting in a place where she can clearly observe what the care provider is doing, while at the same time keeping a distance in order to avoid any interruption of the care provider's work.

Description of the tool

The tasks in the tool are sorted into major and minor task categories. The major ones reflect the physical action used to perform the task e.g. talking, writing on the computer, or reading on paper. The minor categories are the actual task performed, e.g. reading in the client's paper file. Combined, these constitute the total amount of tasks performed by the care providers. The major categories are depicted with a bold font (see Table 1 and Figure 1 below). Only one task can be captured at a time. If the care provider is doing multiple activities at the same time, the observer must determine by the nature of the task which one to record. For example, if the care provider is writing in the client file at the same time as she is taking the client's history, this will be recorded as "Paper – writing – file", and not "Talking – history-taking" since the care provider is *primarily* writing. Talking will therefore always

come second when the care provider is talking at the same time as doing something else. History taking is in this case included in “paper – writing – file”, since the woman’s history is written down in the file. See detailed description in the table below (Table 1).

Table 1: Detailed description of the tasks according to the major (bold) and minor task categories:

	Task	Description	Further comments
Major category	Computer – find		
1.	Client file	Finding client file	Booking visit, ANC follow-up visit, previous pregnancy table Finding the client’s file in the eRegistry by running the search function
2.	Lab/ultrasound results	Looking for lab/ultrasound results	Finding lab and/or ultrasound results
Major category	Paper – find		
3.	Client file	Looking for client file	Booking visit, ANC follow-up visit, previous pregnancy table Finding the client’s file in archive/storage.
4.	Lab/ultrasound results	Looking for lab/ultrasound results	Lab and/or ultrasound result
Major category	Talking		
5.	Education & counselling	Only for the pregnant woman	Process of pregnancy and its complications, Danger signs in pregnancy, Diet and nutrition, Rest, Exercise in pregnancy, Personal hygiene, Use of drugs or supplements in pregnancy (e.g. iron and folic acid), Care of breasts and breast-feeding, Symptoms/signs of labour, Plans of delivery, Plans for postpartum care, Family planning, Harmful habits (e.g. smoking, cultural habits), explaining referral procedure
6.	Talking to family	Talking to client’s family in the clinic	This may take place both during and/or after consultation hours.
7.	History taking	Demographic information and client history (past medical/surgical, obstetric, family; current pregnancy)	Only report as history-taking if care provider is clearly not doing anything else than asking/listening to the client, meaning not writing
8.	Test results from lab/ultrasound	Calling for scheduling tests or results, e.g. lab or ultrasound results from other lab/clinic.	
9.	Clinical support	Talking to colleague about client-related matters, seeking client-related support	Talking to doctor/other nurse about the client, schedule tests (incl. on the phone), meaning not writing
10.	Call client/family	Care provider talks	This may take place both during

		with client or her family on the phone: schedule appointment, getting/conveying results	and/or after consultation hours.
11.	Referrals	Talking related to arranging referrals, high-risk clinic/hospital to notify about referrals	
12.	Technical support	Seeking help in case of technical problems	Technical problems related to either the eRegistry or the internet. Talking to the MCH supervisors/field support
13.	Other		
Major category	Procedures		
14.	Clinical and/or medical examination	Performing examination	Blood pressure, Fundal height, Height, Weight, Pallor, Pulse, Oedema, Breast, Temperature, Foetal presentation and engagement, Foetal heart sound + others. Some of these might take place in another room.
15.	Injections/blood take	Giving injections and taking blood	Most often, tetanus toxoid
16.	Giving tablets		e.g. iron tablets
17.	Other		
Major category	Outside		
18.	Assisting doctor	Leaving consultation room to go to the doctor's office	When care provider follows the client to the doctor's room (especially in the case of a male doctor), or if the nurse assists the doctor in another room than the consultation room.
19.	Examination in other room	Leaving room to perform examination in another room than the consultation room	
Major category	Computer – writing		
20.	Client file (including history)	Entering data into the client's file, including writing during history-taking.	Entering data (from registration, history-taking, examination, lab results) and other documentation in client file, incl. back-up file in case of Internet problems
21.	Lab/ultrasound form	Enter lab/ultrasound results into the system	From lab/ultrasound results paper
22.	Schedule appointment	Write new appointment in the system	Recognises activity either by looking or based on what the care provider is saying
23.	Text message in eRegistry	Writing other places than in the client file, in the eRegistry	E.g. notes, messages to other care providers
Major category	Paper – writing		

24.	MCH handbook (including history)	Write information in the woman's MCH handbook, including writing during history-taking.	
25.	Client file (history)	Write data, including writing during history-taking.	Write data from history-taking, examination, lab results and other documentation in client file
26.	Register book	Write in the register book	
27.	MCH Handbook/register book	Writing in the MCH handbook at the same time as writing in the register book	If the nurse writes in different places interchangeably
28.	Register book/client file	Writing in the register book at the same time as writing in the client file	If the nurse writes in different places interchangeably
29.	Client file/MCH handbook	Writing in the client file at the same time as writing in the MCH handbook	If the nurse writes in different places interchangeably
30.	Lab/ultrasound/prescriptions/referrals	Write orders	Write orders: lab form, ultrasound, referrals, prescriptions
31.	Schedule next appointment	Write next appointment in the appointment book (schedule book)	
32.	Writing on other paper	Any other writing	
Major category	Computer – read		
33.	Appointment list	Read client appointments from the system	Read list of appointments in the eRegistry.
34.	Client file	Reading from the client file on the computer	Only reading without typing or writing.
35.	Lab/ultrasound results	Reading lab and/or ultrasound results from computer	Only reading without typing or writing.
36.	Guidelines, treatment	Searching for guidelines, etc. on the computer	Internet search not in the eRegistry platform
37.	Other info	Any other patient- or health information-related reading on the computer	
Major category	Paper – read		
38.	Appointment list	Read client appointments from appointment book	Read list of appointments in the appointment book.
39.	MCH handbook		
40.	Client file	Reading client information from paper file	Only reading without writing.
41.	Lab/ultrasound results	Reading lab and/or ultrasound results from forms	Only reading without writing.

42.	Guidelines, treatment, official letter	E.g. guidelines, books, journals, official letters	Using books or other literature for guidelines
43.	Other	Any other patient- or health information-related reading on book/paper	
Major category	Between/after consultations		
44.	Statistics book		
45.	Group education		
46.	Cleaning, arranging files	Organising cleaning of equipment, prepare for next client	
47.	Phone/computer: personal	Use of phone/computer for social media, email, etc.	
48.	Other: Eating, praying, toilet etc.	Praying etc.	

How Microsoft Access' data entry form works:

The observer initiates the observation by clicking any of the minor task descriptions under the bold major tasks on the entry form (Figure 1). The click will make the tool record the time. The observer then determines the nature of the current activity and clicks the corresponding button on the form followed by the "Confirm entry" button to store the activity. If the observer realises that she misinterpreted an activity and hit the wrong task button, the observer can simply switch to the correct task button, since the entry of the task is not stored until the "Confirm entry" button is clicked. Similarly, as soon as the care provider switches to a different task or activity, the observer clicks the "Confirm entry" button to complete the current entry. To finish the observation, the observer clicks the "CLOSE" button.

An example may be helpful:

1. Provider starts writing → observer clicks: "computer – writing – file"
 2. Provider starts talking (history taking) → observer clicks: "Confirm entry" → "talking – history-taking"
 3. Provider starts writing → observer clicks: "Confirm entry" → "computer – writing – file"
- It is important to always click "Confirm entry" before switching the task or before ending the whole observation by clicking "CLOSE".

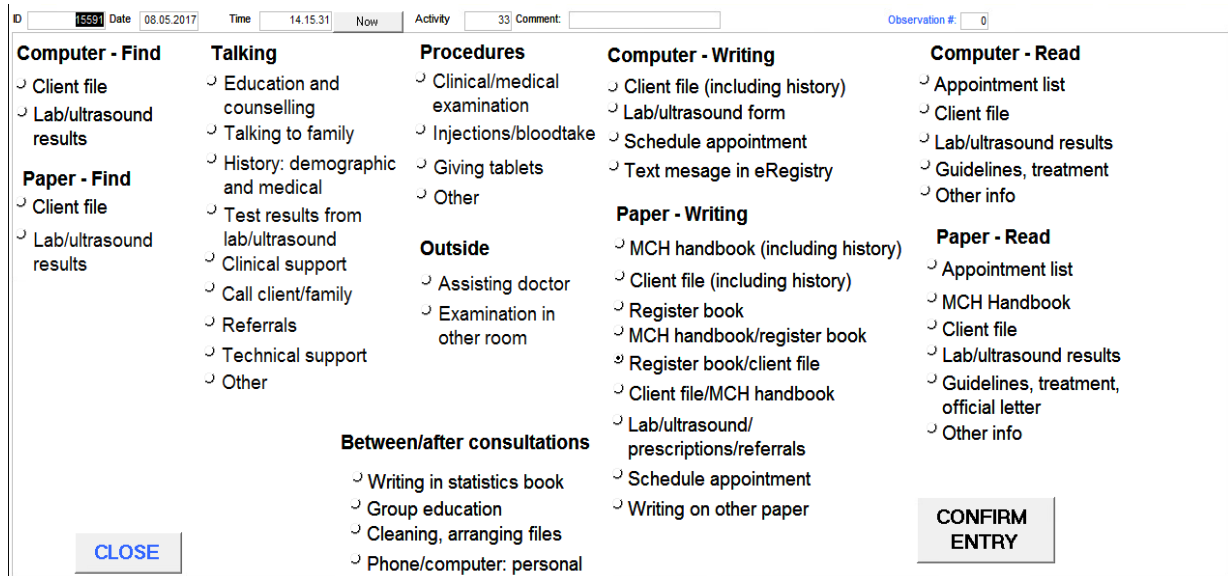


Figure 1: Screenshot of data collection tool

As can be seen both from Table 1 and Figure 1, some of the major categories have an “other” task. This is meant for unexpected activities that the activities described in the tool are unable to capture. For example, if the care provider starts reading something else than any client-related information, then the “Paper – read – other” task button will be pressed. If the observer clicks on an “other” task, then it is important that the observer writes a short comment in the right corner of the tool or on a paper note. This will help us understand if it is necessary to include some other relevant activities in the tool.

At the beginning of each observation, the observer will note whether the consultation is a booking or a follow-up visit. For the observations conducted after consultation hours, this should be stored as one single observation.

C. Stata outputs

1. Wilcoxon rank-sum test for time spent on ANC consultations

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1	obs	rank sum	expected
0	39	940	1014
1	12	386	312
combined	51	1326	1326

unadjusted variance 2028.00

adjustment for ties 0.00

adjusted variance 2028.00

Ho: se~ntime(Contro~1==0) = se~ntime(Contro~1==1)

z = -1.643

Prob > |z| = 0.1003

P{se~ntime(Contro~1==0) > se~ntime(Contro~1==1)} = 0.342

Control clinics = 0, intervention clinics = 1.

2. Wilcoxon rank-sum test for time spent on health information management

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1	obs	rank sum	expected
0	39	948	1014
1	12	378	312
combined	51	1326	1326

unadjusted variance 2028.00

adjustment for ties 0.00

adjusted variance 2028.00

Ho: se~mtime(Contro~1==0) = se~mtime(Contro~1==1)

z = -1.466

Prob > |z| = 0.1428

P{se~mtime(Contro~1==0) > se~mtime(Contro~1==1)} = 0.359

Control clinics = 0, intervention clinics = 1.

3. Wilcoxon rank-sum test, analysis categories

Information access:

```
. ranksum secondsinfacctime , by(Control0Intervention1) porder
```

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1	obs	rank sum	expected
0	27	529	526.5
1	11	212	214.5
combined	38	741	741

unadjusted variance 965.25

adjustment for ties -0.74

adjusted variance 964.51

Ho: $s_{\text{cctime}}(\text{Control} \sim 1 == 0) = s_{\text{cctime}}(\text{Control} \sim 1 == 1)$

z = 0.080

Prob > |z| = 0.9358

$P\{s_{\text{cctime}}(\text{Control} \sim 1 == 0) > s_{\text{cctime}}(\text{Control} \sim 1 == 1)\} = 0.508$

Information documentation:

```
. ranksum secondsinfdoctime , by(Control0Intervention1) porder
```

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1	obs	rank sum	expected
0	38	890	969
1	12	385	306
combined	50	1275	1275

unadjusted variance 1938.00

adjustment for ties -0.09

adjusted variance 1937.91

Ho: $s_{\text{doctve}}(\text{Control} \sim 1 == 0) = s_{\text{doctve}}(\text{Control} \sim 1 == 1)$

z = -1.795

Prob > |z| = 0.0727

$P\{s_{\text{doctve}}(\text{Control} \sim 1 == 0) > s_{\text{doctve}}(\text{Control} \sim 1 == 1)\} = 0.327$

Information reporting:

```
. ranksum secondsinfreptime , by(Control0Intervention1) porder

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1 |      obs   rank sum   expected
-----|-----
          0 |      25      385     412.5
          1 |       7      143     115.5
-----|-----
    combined |      32      528     528

unadjusted variance      481.25
adjustment for ties      -0.71
-----
adjusted variance      480.54

Ho: se~ptime(Control~1==0) = se~ptime(Control~1==1)
    z = -1.254
    Prob > |z| = 0.2097

P{se~ptime(Control~1==0) > se~ptime(Control~1==1)} = 0.343
```

Information processing:

```
. ranksum secondsinfproctime , by(Control0Intervention1) porder

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1 |      obs   rank sum   expected
-----|-----
          0 |      11      71     82.5
          1 |       3      34     22.5
-----|-----
    combined |      14     105     105

unadjusted variance      41.25
adjustment for ties       0.00
-----
adjusted variance      41.25

Ho: s~proc~e(Control~1==0) = s~proc~e(Control~1==1)
    z = -1.791
    Prob > |z| = 0.0734

P{s~proc~e(Control~1==0) > s~proc~e(Control~1==1)} = 0.152
```

Client care:

```
. ranksum secondscaretime , by(Control0Intervention1) porder
```

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1	obs	rank sum	expected
0	34	893	799
1	12	188	282
combined	46	1081	1081

unadjusted variance 1598.00

adjustment for ties -0.10

adjusted variance 1597.90

Ho: se~etime(Contro~1==0) = se~etime(Contro~1==1)

z = 2.352

Prob > |z| = 0.0187

P{se~etime(Contro~1==0) > se~etime(Contro~1==1)} = 0.730

Miscellaneous:

```
. ranksum secondsmisctime , by(Control0Intervention1) porder
```

Two-sample Wilcoxon rank-sum (Mann-Whitney) test

Control0In~1	obs	rank sum	expected
0	17	158	161.5
1	1	13	9.5
combined	18	171	171

unadjusted variance 26.92

adjustment for ties 0.00

adjusted variance 26.92

Ho: s~sctime(Contro~1==0) = s~sctime(Contro~1==1)

z = -0.675

Prob > |z| = 0.4999

P{s~sctime(Contro~1==0) > s~sctime(Contro~1==1)} = 0.294

4. Power calculations, health information management time

Two-sample t-test of the log-transformed health information management variable:

```
. ttest lnsecondshimtime, by( Control0Intervention1) unequal
```

Two-sample t test with unequal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]	
0	39	5.592825	.1277524	.7978137	5.334204	5.851447
1	12	6.024825	.2134706	.7394837	5.55498	6.494671
combined	51	5.694472	.1118735	.7989368	5.469768	5.919177
diff		-.432	.2487777		-.951684	.0876841

```

diff = mean(0) - mean(1)                t = -1.7365
Ho: diff = 0                            Satterthwaite's degrees of freedom = 19.5638

Ha: diff < 0                            Ha: diff != 0                            Ha: diff > 0
Pr(T < t) = 0.0491                      Pr(|T| > |t|) = 0.0982                      Pr(T > t) = 0.9509

```

Power calculation given actual data:

```
. power twomeans 5.6 6, sd1(0.8) sd2(0.74) n(51) nratio(0.3)
```

Estimated power for a two-sample means test
Satterthwaite's t test assuming unequal variances
Ho: m2 = m1 versus Ha: m2 != m1

Study parameters:

```

alpha = 0.0500
N = 51
N2/N1 = 0.3000
delta = 0.4000
m1 = 5.6000
m2 = 6.0000
sd1 = 0.8000
sd2 = 0.7400

```

Actual sample sizes:

```

N = 50
N1 = 39
N2 = 11
N2/N1 = 0.2821

```

Estimated power:

```

power = 0.3118

```

Sample size estimation ($\alpha = 0.05$, power: 80 per cent):

```
. power twomeans 5.6 6, sd1(0.80) sd2(0.74)

Performing iteration ...

Estimated sample sizes for a two-sample means test
Satterthwaite's t test assuming unequal variances
Ho: m2 = m1 versus Ha: m2 != m1

Study parameters:

      alpha =    0.0500
      power =    0.8000
      delta =    0.4000
      m1 =     5.6000
      m2 =     6.0000
      sd1 =    0.8000
      sd2 =    0.7400

Estimated sample sizes:

      N =        120
      N per group =    60
```

D. Suggested Time and Motion Procedures (STAMP)

Adapted from Zheng et al. (14):

Area and element	Description
Intervention	
Type	Electronic registry for maternal and child health (MCH eRegistry)
System genre	DHIS2 Tracker eRegistry
Maturity	June-October 2016
Empirical setting	
Institution type	Public clinics reporting to the Ministry of Health
Care area	Mid-size primary healthcare clinics offering antenatal care
Locale	Semi-urban
Research design	
Protocol	Observational study within an CRCT
Duration	Four weeks
Shift distribution	ANC working days
Observation hours	Total number of observation hours: 30 Number of observation hours in each arm: 20.7 hours (control); 9.3 (intervention).
Task category	
Definition and classification	See Figure 3.
Acknowledgment of prior work	The structure and intuition of the analysis categories was adapted from Pizziferri et al. (17)
Observer	
Size of field team	Three PNIPH employees
Training	Thorough introduction to the methodology, the task categories and what

	they represent, and the data collection tool. Simulation videos were used for familiarising and practicing with the data collection tool.
Background	Nursing and public health.
Inter-observer uniformity	Was not accounted for.
Assignment	Observer 1: Two control clinics, one intervention clinic Observer 2: Two intervention clinics Observer 3: One control clinic
Subject	
Size	Six care providers in six different clinics were observed.
Recruitment and randomization	Subsample from eRegQual. After applying exclusion and inclusion criteria, this leaves a number of 64 PHCs (31 intervention PHCs and 33 control PHCs).
Background	MCH nurses and midwives
Data recording	
Multi-tasking	Multitasking is not captured by the tool
Non-observed periods	In principle, the observer was instructed to remain in the consultation room for the whole day. Therefore, if the care provider left the room, the observer would determine under which task the period of time would be categorised as by assessing whether the care provider left the room with the client (in which case it was believed that she would be taken to see a doctor); or whether the care provider came back with a file (assumed that the care provider went to get the relevant patient file).
Between-task transition	The beginning of a consecutive task marks the ending of the previous one.
Collection tool	Microsoft Access on laptops, adapted from the template made available by the Agency for Healthcare Research and Quality (51).
Data analysis	
Definition of key measures	Outcome measure: time spent on health information management. Unit of analysis: time in minutes per consultation
Analytical methods	Wilcoxon rank-sum test for unmatched samples; bootstrapped confidence intervals, using Stata, version 14.2.

Ancillary data	
Location	Low-risk, mid-size primary healthcare clinics; in consultation rooms.