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# A Semiotic View on Paper and Mobile Care Data Quality

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**Abstract.** Data quality of paper health records remain problematic and little is known about mobile health data quality. A semiotic data quality framework is used as an analytical lens to identify the quality of data in care health service provision in resource-restricted communities. A mobile application was developed using a co-design approach. The results of the empirical study indicate data quality problems on the syntactic, semantic, pragmatic and social semiotic levels. The social aspect of data quality is an important contributor of quality associated problems. It is important to consider this human involvement in the capturing and using of data for the value of care data to be fully utilized. With better quality data a better care service can be provided and ultimately resulting in better quality life.

**Keywords.** Semiotic data quality, care data, mobile health data, contextual collaborative design and development

## Introduction

The quality of paper and mobile healthcare data is a complex concept and the objective of this paper is to unpack these complexities and specifically consider the social aspects. The research question to investigate this phenomenon is: What are the data quality implications of paper versus mobile care data in a particular context? The objective of this interpretive research study is to better understand the complexities of data quality; semiotics was used as an analytical lens to establish these data quality implications.

Firstly the topic is introduced considering the current status of data quality research as reported in related literature relevant to this paper. The persons interacting with data and their producer and consumer roles are considered to provide for the social aspect [1]. Several data quality frameworks [2-3] are available but they, however, do not provide for the reasons why data quality is still a problem and therefore a semiotic data quality framework is used in this paper to view quality from a semiotic perspective [4]. This framework considers specifically the human information function [5].

Semiotics theory refers to how signs and symbols are used to convey knowledge with relations between: syntactic as the relationship between sign representation; semantic between a representation and its referent; and pragmatic between the representation and interpretation semiotic levels [5]. The process of interpretation, called semiosis, at the pragmatic level depends on the use of the sign by the interpreter in the case of data, the data consumer. The sign (data) is not a representation of an objective reality but depends on the shared understanding in the context of the communication process [6].

There are many different definitions and views on quality but the view adopted by this study is quality from the user's viewpoint with the fitness for purpose [7] view.

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An electronic health record (EHR) is not only a replacement of a paper record but a longitudinal record with electronic entries by healthcare practitioners in multiple sites. An EHR includes the patient's health profile and data over time to represent different episodes of care by various providers [8]. The need for a healthcare system that is usable **anytime, anyplace** and to **anyone authorised** is growing [9]. **A mobile record** could be regarded as an extension of the EHR to allow healthcare professionals access to patient data at the point of care but will probably be used in conjunction with EHR and/or paper based components of the patient record [10-12].

A health record has data about the practical "*doing*" of healthcare and as a record "*at work*" in addition to data about a patient and the care of patient [13]. The EHR evolves around a complex collection of related forms, papers, documents and records embedded in the social, spatial context of a healthcare enterprise. Completeness and accuracy are some of the important data quality attributes for healthcare [14].

## 1. Methods

Data quality was conceptualized based on it being regarded as complex, multi-dimensional with human involvement [15]. The research was therefore approached from a subjectivist interpretive viewpoint.

In home-based healthcare the collection and processing of data is highly contextual; each service provider using their own data element definitions. Reporting depends on the requirements of the authorities and the actual care records are structured to support this and the specific needs of the care service provider. An ethnographic study was conducted on specific communities to understand the contextual aspects of providing the care service. Open ended interviews were conducted and the care process as well as the co-design activities were observed to obtain better insights of the care givers' activities in practice. Several copies of the care forms were studied to obtain a better understanding of the data structures and use of data elements and values captured and used. The current paper-based system no longer effectively supported the needs of the care service provider with problems with care data collection, reporting and utilizing their data. Mobile solutions seemed to be appropriate for the context of these communities with mobile connectivity in most cases the only connectivity option. Since the contexts played such an important role in the manner that the communities institutionalized their practices the care givers were actively involved in the design and development process of the mobile solution. Service design methods provided useful mechanisms to involve the end-users in co-designing the mobile solution. IT interns developed the mobile solution using open source software. They were part of an innovative hub where students from different disciplines, levels and cultures worked closely with each other and the communities. The mobile care data application is currently functional and ready to be deployed.

In this paper the consideration of data quality of the paper care data versus mobile care data is reflectively evaluated using semiotics as an analytical lens.

## 2. Results

The burden of disease is high in the communities investigated with a high incidence of HIV/AIDS and TB patients and many of them suffered from both conditions. Most of the persons in the community are unemployed and poverty is a major issue. There is no health clinic in the community and the care service provision is provided by a NGO in the town close to the township. Care givers are mostly from the community and have limited training and work for a small stipend. They often provide basic services beyond their formal care provision such as cleaning the house, cooking meals, run errands, etc. Most of them are illiterate or semi-literate and have to use English, the language of reporting the discussions. There is limited electricity and connectivity in the community. Most patients and care givers have mostly the cheaper versions of feature mobile phones using pay-as-you-go mobile time.

Each patient has a care plan in a paper folder with the patient's condition and treatment details. This forms the basis with instructions for the care giver with a copy kept at the facility. Most forms have some free text fields, e.g., the patient name, diagnosis, etc. Care givers complete a care visit form based on their observations of the care activities. The data is mostly a check list, e.g., duration of visit, HIV/AIDS and TB adherence, blood pressure, etc. Care givers sometimes complete forms only at night after the visits. Sometimes the forms are damaged due to weather conditions as they walk to the homes. Once a month a monthly summary report is completed with data aggregated from the forms to be captured on a spreadsheet.

The data according to the syntax, semantic, pragmatic and social world semiotics level are indicated next in an abbreviated form. The **structure** for the syntactic level for the paper data quality is acceptable, paper care plan and visits forms are in the form of a template with headings and places for the data. Incorrect values are captured when headings are not clear. Data transferred, calculated and summarised are problematic because the format of the forms differ leading to incorrect data being captured. Mobile care data quality is better than paper care data because the flow of the data captured and the labels and menu options on the mobile interface are the preferred names provided by the care givers and nurses during the collaborative design process. The physical design of the mobile care record represents the logical design to support the workflow established during the design.

On **the semantic** level the data may be **incomplete** with values not in all cases captured, e.g. when the care giver does not understand the data element or forgot to capture at the point of care. Mobile care data may be more complete because the required and specified data values are entered as guided by the mobile interface. Both paper and mobile care data may become **incorrect** over time, e.g., if a patient is not visited (status change of condition, change of address, etc). Paper care data can be **ambiguous** with different patients of the same household appear on the same form without being of the same family. The mobile care record is designed with a record for each patient connected with a household relationship. Paper care data is not always **consistently** captured (text; dates; capturing age when the ID is not known). For mobile care data check boxes, drop down lists are mostly used enforcing consistent value capturing and for dates the expected date format is indicated. The paper data elements on the different care forms **have meaning** for the different care activities based on their training but may not be meaningful in all cases for new care givers or someone who struggles with English. All the data elements of the mobile care record are the result of a co-design process and were suggested by the end-users, the care givers, nurses and administrators. The organisation of the data elements on the mobile phone supports the different care activities based on the suggested flows but still requires care givers to be trained.

On the **pragmatic** level **access** to care data may be problematic. The care plan and forms are only available at the patient's or care giver's home and at the facility. Once the care forms are submitted, they have no access to historical data. Only authorised persons have access anytime and anywhere to mobile records, provided there is connectivity and power to charge the phone battery. The **presentability** of paper care data depends on the forms (templates) and the space available to write and may be problematic for additional information or for a large handwriting. Most of the mobile data values are captured using drop down boxes with the selection of a list of possible values and the navigation between the different screens as considered during the co-design process. The size of the text, the position on the screen and the amount of data per screen are all according to the preferences of the end-user. The way the care givers **understand** the data elements on the forms depends on their experience, their training and their literacy level. The ease to **aggregate** and the **flexibility** of paper care data are problematic because these need to be calculated and transferred with the totals calculated to other forms in other formats. The reporting data is **fixed** for each authority making it difficult to modify or utilise the data differently. The mobile care data are automatically aggregated and **flexibility** will depend on the ability to generate new reports or queries for different contexts or care service providers. Paper care data is not **secure**, the patient's data is available to anyone who has access to the forms. Security mechanisms are incorporated in the mobile application to control access to the different parts of patient data and for **privacy**. The care data is valuable to the service providers but also to monitor the condition and treatment of patients to intervene or change when necessary. Important patterns and trends can be identified for the authorities to respond. The mobile application provides more data than the paper forms because it provides access to historical data; has more options (e.g., photo of a wound); with access to educational information or explanations. Both paper and mobile care data elements are **relevant** to the care givers' tasks to record their observations and care activities performed and for the care facility to manage their care service.

On the social level several problems were noted with regards to how the paper data supports the care activities and **communication** between the different stakeholders to facilitate **their relationships**. The stigma of HIV/AIDS influenced the patients' honesty with regards to data, e.g., hiding their clinic cards. There are many semi-literate and illiterate persons in the communities influencing what is recorded. Care givers tend to write long free text reports when they do not understand the data elements making aggregation problematic. There are often socio-economic related problems that influence care giving such as looking after children; cooking food, etc. English is often the second or even third **language of** the care givers and patients and in many cases this results in serious data quality problems when capturing data. The care givers have their **own indigenous knowledge** about, for example, the use of traditional medicinal herbs and plants for some conditions that are not recognised in western medicine. Care givers do not have easy access to information or training since they are mostly from the communities they serve which are often isolated.

## 3. Discussion

The findings derived from the results using the semiotic levels as an analytical lens are: the data quality of both paper and mobile care data is influenced by several factors, especially relating to humans, on all the semiotic levels with a slight improvement for mobile data; data quality is highly contextual based on high people interact with data in a context; the social level quality aspects influence all the other levels, namely the structure, meaning and pragmatic use of data and can therefore not be ignored.

The quality of data is not only to what extent it supports the purpose for which it is used but it is important to understand who the person is who interacts with the data as producer or consumer and how they interact in the context. It is important to specifically consider the quality of care data through training and to actively do something to address quality problems because care data is crucial for addressing health problems. Care data is a valuable resource of information about many persons who do not have easy access to formal health care services. Currently only aggregated care data is utilized beyond the care service provider and individual patient data need to still be integrated with the national health system. Only when quality of care patient data is acceptable will it be possible to implement a single patient health record for each person. Any national health strategy needs to provide for the local contexts.

Data quality remains a complex problem and need to be actively addressed on a social level in addition to the other levels before care data could be fully utilized and integrated in a healthcare system. Although m-health solutions show promise in not only extending access to patient data it could also result in better quality care data but only if all dimensions of data quality as well as the human involvement are considered.

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