

Exploring barriers for health visitors' adaption of the Danish Children's Database through an empirical study

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Abstract

Denmark has unique health informatics databases such as "The Children's Database" (CDB), which since 2009 has held data on all Danish children from birth until 17 years of age. In the current set-up a number of potential sources of error exist - both technical and human - which means that the data is flawed. The objective of this paper is both to clarify errors in the database and to enlighten the underlying mechanisms causing these errors. This is done through an ethnographic study using participant observations, interviews and workshops. Additionally, errors are documented through statistical analysis. The data show redundant records. This redundancy can be explained by multiple transmissions conducted by end users or systems, or a lack of validation methods in the National CDB. In our results three types of cases are presented: from health visitors at school, from health visitors visiting families and from health visitors at central health offices. Results are discussed from a socio-technical perspective using Schein's cultural theory to understand the interaction between the health visitors and the information technology used for collecting data. Cultural theory is used to explain the underlying socially constructed mechanisms that cause errors when using the information technology.

Keywords: Public Health informatics, Organizational Culture, Community health nursing, Point of care systems.

Introduction

In spring 2009 a new public health informatics (PHI) database was established by the Danish National Board of Health (NBH): "The Children's Database" (CDB). The objective of the CDB is to monitor the health of all Danish children in order to detect infants at risk at an early stage [1,2], illustrated in fig. 1.

The CDB holds specific information on all Danish children and adolescents aged 0-17 years.

For the current pilot version of the database, only data about height, weight, passive smoking and breastfeeding are collected. This database is unique both internationally and nationally as it represents a national database holding health related information on a *complete* population. However, spot checks performed by the NBH show that the data are flawed. Therefore, they are not used for either primary (e.g. monitoring) or secondary purposes (e.g. research).

Experience shows that besides technical causes for invalid data in health information technology (HIT) databases – including PHI databases – data validity is closely related to the way data are entered as well as the time between data collection and data entry [3]. Experience also shows that when clinicians find HIT systems inappropriate to their work

practice, they develop workarounds, including workarounds related to data entry [4].

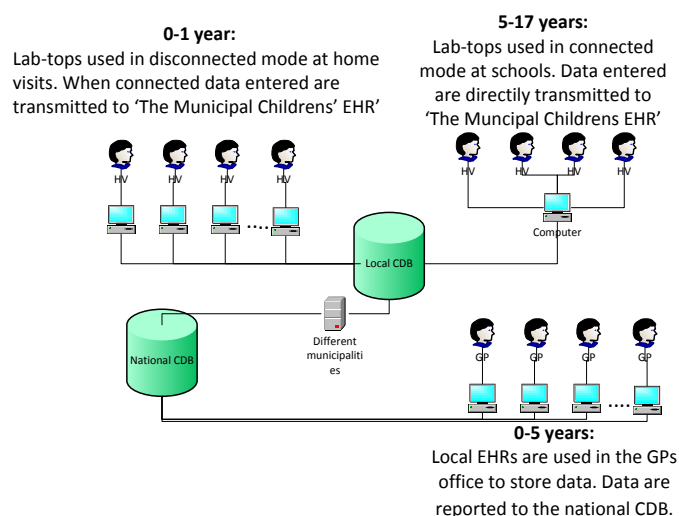


Figure 1 illustrates the setup of the CDB. There are multiple health visitors (HV) communicating information to the CDB in different 'modes'. [1]

During the past decades researchers from the Danish Centre for Health Informatics (DaCHI) at Aalborg University have been studying socio-technical interactions between users and HIT systems in order to develop new methods for studying, developing and evaluating HIT. Research both within and outside DaCHI shows that in contemporary clinical work practice, clinical work and health information technology are so closely integrated that user involvement during the development process is a precondition for the development of HIT systems providing clinical benefits, and hence for minimizing the clinicians' need for workarounds [5-8]. However, even though user involvement is known to be a very important success factor when developing HIT systems, no empirical studies of user involvement in the development of PHI systems for the primary sector seems to have been conducted. In response, DaCHI researchers in collaboration with researchers from University College North Jutland (UCN) have carried out a research study with a primary focus on the interactions between health visitors and the Children's Database system in two Danish municipalities during 2012. The objective was to gain a deeper insight into the health visitors' work practice, including any workarounds. In addition, a data study was carried out in order to study potential technical causes for invalid data.

The objective of this paper is both to clarify errors in the database and to explore the underlying mechanisms causing these errors, thereby providing the insights gained on end user interaction with PHI systems to management and developers. This will allow for the exploration of new avenues in PHI systems development in order to support, facilitate and improve real end-user participation, and hence minimize workarounds.

Materials and Methods

The NBH requires data from the 98 Danish municipalities to be entered into the national CDB in three different ways: 1) Up to one year of age, data collected at either home visits or at the central health office by health visitors are entered into decentralized, municipal, local CDB systems (4 heterogeneous systems in Denmark); 2) Between one and five years, data are entered into primary care electronic health record systems during visits to primary care physicians (11 heterogeneous systems in Denmark); and 3) In primary school, data are entered into decentralized, municipal, local CDB systems during visits by the health visitor or physician to the schools (4 heterogeneous systems in Denmark). Data from the decentralized, municipal, local CDB systems and the primary care electronic health record systems in each municipality are transferred to the national, central database CDB once a day.

During 2012, an ethnographic study on the interactions between health visitors and the municipal, local Children's Database was conducted at home visits, at school clinics and at the central health office in the County of Aalborg (Aalborg municipal CDB system) and the County of Hedensted (Novax municipal CDB system). A study of data from the two municipal, local CDB systems in Aalborg and Hedensted and from the national, central CDB database was also conducted. Data extracts from the two local databases and the national database were in both SPSS format and Excel format. We created a MySQL database to handle and manage our data, and used SQL queries to find redundant records. We used SPSS as a back up to determine whether the results from our database were correct, using the SPSS 'Duplicated cases' function; in MySQL we generated our own SELECT statements. All data were collected and analysed as presented in Table 1.

Table 1 illustrates data collection and analysis

Data collection	Techniques used for this study	Data analysis
THE ETHNOGRAFIC STUDY		
Observation	Non-participant observation of health visitors at home visits 8 days, health visitors at school clinics 7 days and health visitors at a consultant office 4 days. In average 5 children were examined pr. day.	Analytical coding, categorizing and condensation of observation data with a focus on the interactions between users and technology – and an "open mind" towards other themes
Informal interviews	Informal interviews with the 19 observed health visitors	As above
Workshop	Activity-based workshop, parted into	As above

	two levels (validation-level and creativity).	
THE DATA STUDY		
Technical analysis	Data about CPR (central personal registration number), height and weight for all children from the municipality of Aalborg and Hedensted, aged 0-17 years, during the period of 1. April 2009 to 1. June 2011, were studied (~130000 records). Document analyze of system and database description.	Simple SQL-query for identification of redundant records. Analytic work on infrastructure, database and system design of the identified redundant records.

Trustworthiness with respect to the ethnographic study was sought through presenting our interpretations to the involved health visitors at the workshop, and through thoroughly describing all activities throughout the process (transparency).

With respect to the data study, permission to access person-level data was obtained from the Data Protection Agency, The National Board of Health, municipality of Hedensted and the municipality of Aalborg.

Theory

The views presented in this paper are based on the combination of the following two theories:

- The socio-technical theory
- Schein's Organizational culture theory

These theories will briefly be introduced.

Socio-technical theory

Socio technical theory is characterized by a view of technological innovation as an adaptation process, during which both the technology and the user's work practice are changed through mutual and lasting impacts [8]. However, if social balance in the work is to be attained when implementing new technology, both social and technological needs must be met, and users have to be involved in the development process. A broad concept of technology is introduced in Socio technical theory, focusing on the micro-level and the actor as opposed to the macro-level. According to this concept, technology embraces: technique, knowledge, organization and product. These four constituents are inseparable components of any technology. A qualitative change in any one of the components will eventually result in supplementary, compensatory, and/or retaliatory change in the others. In the present study, socio-technical theory was used as a framework to shed light on *the interactions* that occurred between the health visitors and the Children's Database system.

Schein's Organizational culture theory

Edgar H Schein defines organizational culture as: "A pattern of shared basic assumptions that the group learned as it solved its problems that has worked well enough to be considered valid and is passed on to new members as the correct way to perceive, think, and feel in relation to those problems" [9]. Schein has developed a model aiming at emphasizing how culture works and how it can be understood (fig. 2).

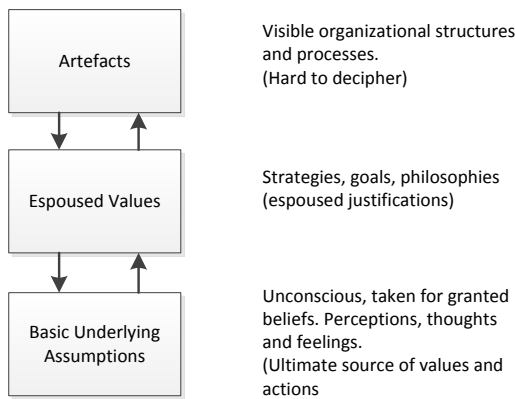


Figure 2 illustrates Schein's model of culture [9]

Schein identifies three distinct levels according to which culture can be analyzed: firstly the visible *artifacts* and behaviors, secondly the espoused values and thirdly the basic assumptions. According to Schein, in order to understand culture and values, it is imperative to delve below the organizational surface and uncover the basic underlying assumptions. These basic assumptions are the deeply embedded, taken-for-granted behavior, which is usually unconscious, but constitutes the essence of culture. Besides, they are typically so well integrated in the office dynamic that they are hard to recognize even from within. Thus, taken for granted assumptions are so powerful because they are not debatable.

The cultural model described by Schein is used in the present paper to understand the mechanisms within the organization that leads the health visitors to act in the manner they do.

The Socio-Technical- and Schein's Organizational culture theory are both well known. What is new is the act of combining them and employing them within the healthcare sector, which has not been done previously.

Findings

The ethnographic study shows that workarounds are developed by health visitors both at home visits, at school clinics, and at the central health offices. The workarounds are primarily related to data entry, where the health visitors are observed not to use the CDB for primary registration of data, but instead use sheets of paper, notebooks or post-it-notes. Empirically, this work practice involves a risk of registration errors, thus it affects the data validity [3]. The analysis of the observation data has revealed several possible reasons for these workarounds:

The interior of the health visitors' work place

The study shows that the interior of the health visitors' work place plays an important role with respect to data not being entered directly into the CDB: a) For toddlers' examinations carried out in the citizen's home, the health visitors bring an ordinary laptop with a screen size of approx. 14 inches. It is typically placed on a table, while the examination of the child typically takes place in the kitchen, bathroom or on the floor in the living room - never at the place where the computer is located. The measured weight and height are noted on a piece of paper and entered into the computer later on - either in the home when the examination is completed, or when the health visitor is back at the office; and b) When toddler's examination is carried out at the central health office, the location of the computer depends on the distance to, e.g. the

power outlet and the internet connector. The computer is typically located at a distance from the examination table, the scales, and the measuring tape. The measured weight and height is noted on a piece of paper at the examination table and then later on entered into the CDB. c) Schoolchildren's examinations typically taking place in a special room for health examination at the schools, and the computer is placed on a desk. The initial interview with the schoolchild takes place at the desk, while the measurement of height and weight takes place somewhere else in the room. Data is noted on a piece of paper and either entered directly into the CDB after each single examination, or at the end of the day when all examinations are completed.

Overall, the observations show that the placing of the computer does not support the health visitors' work practice. It does not allow health visitors to enter data directly into the CDB, but forces them to write data on a piece of paper and then later enter them into the CDB. Experience shows that if technology does not support the work practice which it is supposed to be part of, there is a risk that users will develop workarounds in order to be able to carry out their daily work, which poses a risk to data validity [3;4]. Experience also shows that workarounds, as described above, increase the risk of typing errors and errors of understanding, and that the risk of errors increases with the time between data collection and data entering - e.g. if data are collected and first entered for more children at the end of the day or the following day. Besides these types of errors, there is also a risk that data will be entered into the wrong record [10].

Data discipline - health visitors entering data into the CDB

The study shows, moreover, that health visitors' data discipline is important with respect to data validity. Health visitors often enter data on weight and height into the CDB based on information provided by the children's parents by telephone. These data are initially measured by the primary care physician at a children's examination and communicated to the parents. Thus, the data have passed through several links before they are entered by the health visitor into the CDB, thereby posing a risk for transmission errors, hence to data validity [10].

Changing data in CDB

Data from the interviews shows that if the health visitors discover that they have entered data incorrectly into the CDB, they modify the data later on. This also poses a risk of error. This is also seen in the data study where numerous redundant and flawed records are observed.

Data analysis

Taking both municipalities, we find that in the National CDB there are 13.5% redundant records, with an individual difference between redundancies in the systems. Data analysis from the different systems are illustrated in tab. 2

Table 2 illustrates the frequency of redundant data in the national CDB

System A		Frequency	Percent	Cumulative Percent
Valid	Duplicate Case	7669	14	14
	Primary Case	47116	86	100
	Total	54785	100	
System B				
Valid	Duplicate Case	319	7,9	7,9
	Primary	3726	92,1	100

	<i>Case</i>			
	<i>Total</i>	4045	100	

Looking at the records from both municipalities and comparing these to the data in the National CDB we see that there are more records in the local databases than in the National CDB, i.e. the transfer of records is only partial. But the number of redundant records is identical to what has been identified in the National CDB. Our analysis assumes that data observed on the same day on the same child is redundant. What is troublesome is that data has been reported on several different days –up to 14 different times. This is troublesome because we cannot identify the exact reason for these incidences. Is it because the HV is reporting the data several times? Is it simply because of a poorly designed validator or an unintended repetition of data? How can this data be re-used when it is filled with flawed data?

Another disturbing observation in the data is that in approx. 5% of the records include corrupt data i.e. different observations on same date on the same child regarding weight or height. Table 3 is an example of this.

Table 3 illustrates an example from data on corrupt data

Primary key	DateOBS	DateRep	Height	Weight
#a#	10/12/17	11/01/04	72	8800
#a#	10/12/17	11/01/04	72	9800
#a#	10/12/17	11/01/04	71	8800

Apparently, erroneous data has been reported, but not deleted even though this is possible with one of the methods in the reporting Webservice. The method for this is `DeleteChildMeasurementReport()` or `ModifyChildMeasurementReport()`. These calls are valid for deleting and modifying a record.

Infrastructure and communicating method as possible reason for data errors

The communication between local and national CDB is a web service-based communication. This indicates that communication is applied to the SOA-oriented web service model, described in [11].

The infrastructure is deemed to be secure and shields the transmitted data because the sensitive nature of patient data. [12] The IT-architecture supports the use of web services as a method for sharing sensitive data.

An IT-architecture has to be reliant on stable and secure infrastructure, which can handle requirements as valid data and seamless co-operatively between users (i.e. health visitors to local CDB to national CDB).

The current architecture in Danish eHealth has been heavily influenced by the Danish health care organizational factors. Heterogeneous EHRs [13] are the results of autonomy in selecting EHR systems in different regions.

We found that the web service used for reporting data to the national CDB includes several methods for both generating records and deleting records. So the question is whether these calls for methods in the web service have been implemented in the decentralized heterogeneous systems.

Database designs as possible reason for data redundancy

The process of designing databases is often divided into two levels; a level with domain experts and a level with database developers. Domain experts specify the purpose and the end-user requirements for the database. Database developers

transform the end-user requirements to a database through an entity relationship (ER) model.

According to Wang [14] a preliminary conceptual framework must be met if a requirement to the database design is useful data with quality and validity. The framework consists of four basic elements; 1) accessible, 2) interpretable, 3) relevant, 4) accurate.

The national CDB is designed according to this framework. However, it seems that accurate data is only implemented as in a single tuple and not with a possibility to avoid inconsistent data across tuples, which is why several tuples on the same observation date with different values. Apparently, the national CDB is also complying to be relevant, but again this is considered on a tuple level and not on a record level why redundant data is found.

Interactions between health visitors and technology

The focus in this section is to understand the interactions between health visitors and technology. The study show that most health visitors feel that the computer interferes with their attention and their relationship with the family and the child, and that the technology interferes with the contact and intimacy to the family. This has an important impact on whether they use technology or not. In one of the observational studies, it was observed that the health visitor chose to write data on a sheet of paper, even though the computer was located right next to her. Afterwards, the health visitor was asked whether she saw the computer as a barrier. She replied that she had no problems using the computer and electronic equipment in general, but thought that it took her attention, if she was sitting and looking at the computer while she was talking to the child.

During the observation study, workarounds could at first glance be conceived as a tangible and clear pattern of behavior. But through the analytical study of health visitor's historic and learning background, the more invisible levels of values and basic assumptions are exposed, yielding insight into the root causes of the development of workarounds. Thus, health visitors have a fundamental assumption that presence, contact and attention are important phenomena in working with children and families, and hence data entry carries a hegemonic meaning. [15] As an example, a health visitor said during an interview: "You have to understand that I must first and foremost focus on the contact with the family".

According to the National Health Service, nurses (including health visitors) must provide an individual supportive guidance[12, 16], where values such as trust, respect and intimacy are emphasized[17]. Besides, in the mind of the nurses, home visits are perceived as a form of feast or gift exchange [17]. These values underlie the common basic assumptions, developed by the health visitors as a professional group, about how work is to be performed, how the families are best supported, and how presence and awareness are best created. These basic assumptions will subconsciously affect how health visitors use the CDB. The technology is not perceived as neutral but as value-laden or value active and challenging, thus jeopardizing the trust-based contact with the child and the parents – a contact, which is crucial for the health visitors' work [10]. The way the health visitors interact with the technology therefore plays an important role with respect to transforming and organizing the visit in different contexts.

Cultural Analysis - when the basic assumption is that the computer intervenes in contact, relationship and intimacy with the family and child

It is interesting and perplexing that health visitors perceive data entry as a distraction, while it is not experienced as attention deficit to write down the same data on paper. Schein emphasizes that the concept of culture can be very useful to explain some of these seemingly perplexing and irrational aspects of behavior and attitudes. According to Schein, any group with a stable membership and a common history has developed a culture. Embedded in this culture are common basic assumptions, which are taken for granted and maintained by members of the group through external adaptation and internal integration. These values and assumptions are passed on to new members as the correct way to perceive, think and feel in relation to specific issues. Schein argues that culture is manifested at different levels, depending on the degree to which cultural phenomena are visible to the observer. These levels range from the tangible and distinct manifested artefacts that can be seen, to the deeply embedded and unconscious basic assumptions, defined as the core of culture.[9]

Basic values and assumptions are difficult to challenge or debate because of their deeply embedded and unconscious nature, meaning that they are difficult to change[18]. Thus, they are important factors contributing to the health visitors' development of workarounds instead of entering data directly into the CDB. To question basic assumptions often triggers insecurity. According to Schein, the responsibility for changing culture primarily rests with management, as organizational culture is partly created by management, and because one of the most important tasks for management is to create, manage and - sometimes - to break down culture[18].

Conclusion

The objective of this paper is both to clarify errors in the database and to explore the underlying mechanisms causing these errors.

We have identified the kind of redundancy occurring in the national CDB. There exist both corrupted redundancy, i.e. flawed data and duplicated redundancy, i.e. repeated record transmitted multiple times (a max of 14 times on the same record). We have clarified that the methods in the web service provide the possibility for the decentralized CDBs to delete or modify faulted records and that the basic database design framework is fulfilled. We have enlightened the underlying mechanisms causing these record errors by analyzing our finding in a STS-perspective and explained the culture in health visitors' organization.

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