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Original Research Article

A Methodology to Assess Data Quality at the Patient-Provider Interface of a Public Health Program: A Case Study of a School Dental Service in Sri Lanka

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Abstract: High-quality data generated in routine management information systems is crucial for the success of long-term public health programs since inadequate data quality can result in erroneous decisions, leading to wasted time and resources and underperformance of such programs. Data quality is measured in multiple dimensions and there can be important differences in how data are generated and compiled depending on the local context. As data quality is context-dependent, a quality assurance method is needed that fits the local context with adequate validity and reliability. A method and data quality measurement tool were developed using desk reviews, key informant interviews, and a modified Delphi technique. The method was implemented in a case study to measure the data quality at the patient-provider interface of the school dental service in Sri Lanka, giving attention to the diverse characteristics of the data generation process. The method involved an item checklist. The relative importance of item structure was considered during item selection. Weighted averages were calculated to determine the data quality at the patient-provider interface. The proposed method to develop a tool and assess data quality in public health programs could be applied as a guide in similar contexts.

Keywords: Assessment, methodology, public health, data accuracy, data quality.

INTRODUCTION

Describing disease patterns, measuring public health outcomes, evaluating the impact of public health interventions, and developing need-based policies rely on high-quality data (Barr-Walker, 2017; Hong Chen, Hailey, Wang, & Yu, 2014; Fontaine, Ross, Zink, & Schilling, 2010). Therefore, data quality assessments in public health information systems are now well-endorsed. Since data quality is regarded in multiple dimensions and due to the complex nature of the data generation process, quality concerns may arise at different levels, from data generation to information generation (H Chen, Yu, Hailey, & Wang, 2014). Inadequate data quality renders the information produced by systems useless (Alipour & Ahmadi, 2017; Hong Chen *et al*., 2014; Kerr & Norris, 2004). Consequently, conducting regular assessments of data quality in management information systems is critical to ensuring system robustness.

Since data quality assessment is primarily based on measurement theory (Karr, Sanil, & Banks, 2006), the assessment methods must be precisely defined. Therefore, studying the different methods adopted by other studies and operationalising the attributes into measurable items that are valid and reliable is vital to fit the local context (Alipour & Ahmadi, 2017; Chen, Hailey, *et al*., 2014; Sidi *et al*., 2012). A comprehensive review of existing data quality methods revealed that many lack systematic approaches to include multiple matrices associated with each quality dimension (Chen, Hailey, *et al*., 2014). Many studies lacked clear definitions of attributes and measurement indicators of each dimension, highlighting the need for consensus on what attributes should be measured (Chen, Hailey, *et al*., 2014; Batini *et al*., 2009;

Alipour & Ahmadi, 2017). We aimed to overcome these drawbacks in a case study to measure the data quality at the patient-provider interface of the school dental service (SDS) in a district in Sri Lanka.

MATERIAL AND METHODS

The development of the data quality measurement method and checklist followed a phased process. First, extensive desk and literature reviews were conducted to understand the data generation process in the management information system (MIS) of the School Dental Service (SDS). Next three rounds of consultative meetings were held with four community dentistry experts, introducing them to commonly used dimensions of data quality including accuracy, clarity, completeness, consistency, precision, and timeliness, as derived from existing literature (Hong Chen *et al*., 2014). A modified Delphi technique was used to reach a final consensus on the important data quality dimensions and to establish operational definitions. These dimensions were agreed upon as accuracy, completeness, and timeliness, considering their respective relevance to the domains in the operational field Subsequently, operational definitions were formulated based on these dimensions.

The patient-provider interface where the initial data are generated when the school dental therapist (healthcare provider) interacts with the child (health service consumer) was defined as facility level one. The Register of Patients (PR) and Daily Record of Treatment (DR) were chosen for data quality assessment at this level.

Overall completeness was operationalized by considering both external and internal completeness. External completeness was measured by calculating the percentage of available records out of the total child records. Internal completeness was determined by assessing the proportion of items in each student record with non-missing values. To measure completeness at facility level one, real-world data was crosschecked against entries in the PR and DR. To assess accuracy, the content and contextual correctness of data fields at facility level one was evaluated. The PI examined the child and findings were compared with the recorded details to measure content accuracy. The contextual accuracy was determined by adherence to the guidelines on Management Information System for School Dental Service 2009. Spelling errors were considered accurate unless they resulted in a different meaning. Accuracy was measured only for completed fields. The entries were considered as timely if they were updated within one week of the patient's visit in both DR and PR.

The records of 1041 child patients were examined and their respective records were assessed using the new method. The retrospective cross sectional study design was employed.

Informed consent from the parents were taken, with all necessary administrative clearances. The ethical clearance was obtained from the ethics review committee of the Faculty of Medicine at the University of Colombo.

Item selection for data quality measurement

The PR and DR records contain data fields that were treated as individual items. These items were grouped into subsections based on their content, including General Information, Examination Findings, and Care Provided. To assess the importance and relative impact of each subsection, record, and selected domains of accuracy, completeness, and timeliness to the data quality, a 4-point Likert scale was employed. A total of eighteen experts participated in this process, spanning national policy-making levels, district administrative roles, and operational positions. The experts were given a self-administered checklist containing all items found in the PR and DR records. They utilised the 4-point Likert scale to assess the relative importance and contribution of each subsection record to accuracy and completeness. Furthermore, the relative significance of accuracy, completeness and timeliness to the overall quality of the data was also gathered.

The scores provided by the experts for each item were totaled and averaged. The equal spread scale method was then employed to determine the relevance level for each item field.

$$\text{Importance} = \left(\frac{\sum_{n=1}^{18}(\text{value given by experts under 1 to 4 Likert Scale})}{number\ of\ experts} \right)$$

n = number of experts

Each item's average score was assigned to one of four levels of importance, calculated with a gap of (4-1) / 4 = 0.75 between each level in the four-point Likert scale measurement (ranging from 1 to 4). Beginning with the minimum level of one, 0.75 was added to determine the starting point of the next level at 1.75. This gap of 0.75 was maintained between each category. The item averages of the key informants all ranged in the upper middle and upper levels. Therefore, all the items in the documents were included in the Data Quality Assessment (DQA) checklist.

A pre-test was conducted to determine the feasibility of data collection and the time required to complete the DQA. The final version of the DQA, along with an instruction sheet, was developed following the pre-test.

Development of the weighted method for data quality measurement

The weights for each item, subsection, document, and data quality domain were calculated, assuming the final importance for each item given would reflect the interest of academic, operational, and practice levels of data quality.

$Weight\ (I_i) = \left(\frac{Average\ score\ given\ to\ each\ item\ by\ experts}{4}\right)$

I_i = weight of the item/ weight of the sub-section/ weight of the document and domain.

The following methodology was followed to achieve the data quality at facility level one (Figure 1).

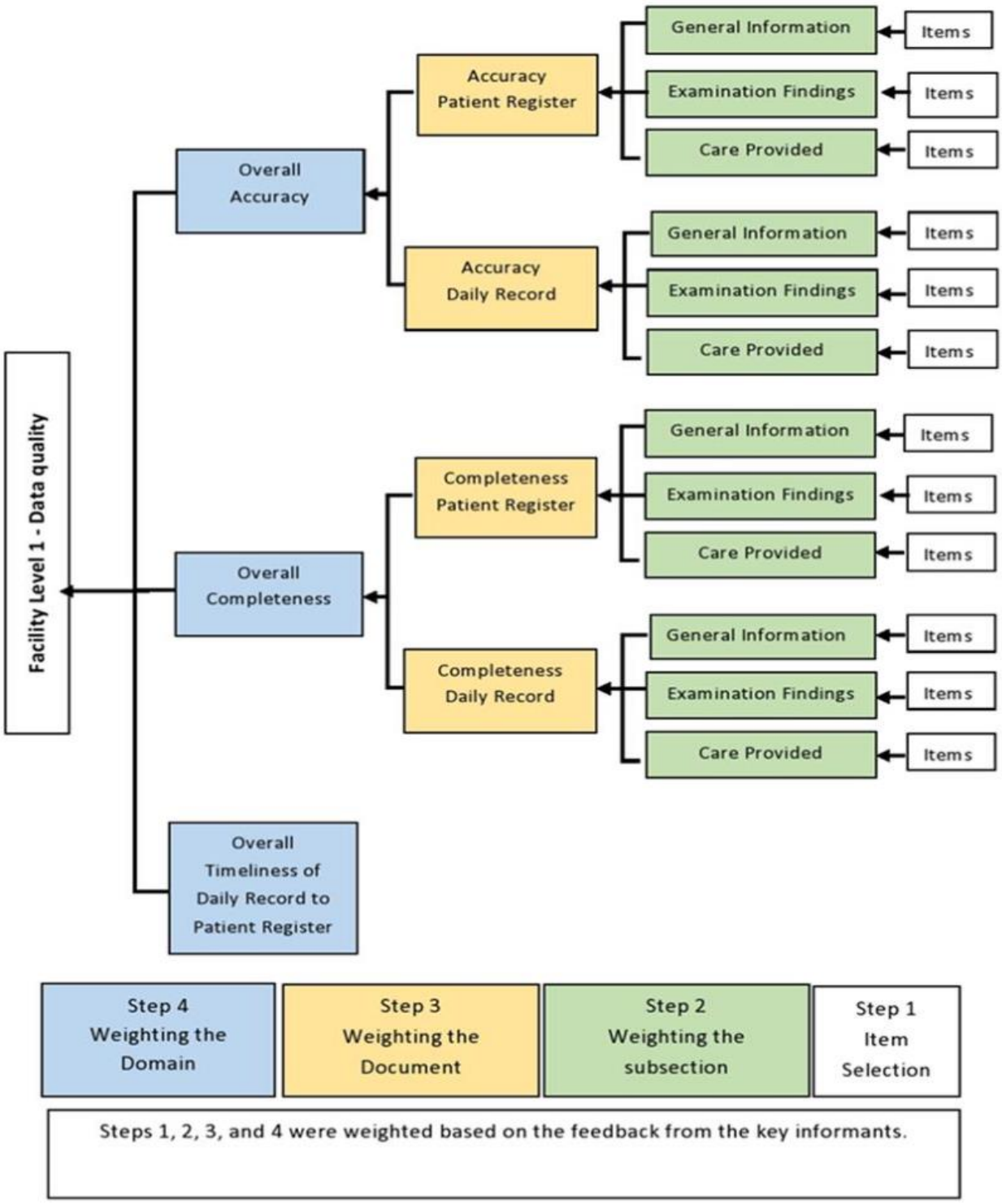

Figure 1: Schematic presentation of arriving at final data quality at facility level 01

Calculation of accuracy/completeness of the subsections of each document

Each subsection of DR/PR is composed of a set of items. The value for each subsection was computed using weighted totals of each item.

$Subsection_i = weight_a . Item_a + Weight_b . Item_b + \ldots\ldots Weight_n . Item_n$

$Subsecion_i$ - Accuracy/Completeness of each subsection of DR/PR in i^{th} record

$Weight_a$ Weight for item a
$Weight_b$ Weight for item b
$Weight_n$ Weight for item n

Weights generated by expert responses to each item

$Item_a$ Value for item a
$Item_b$ Value for item b
$Item_n$ Value for item n

Research findings

Calculation of accuracy/completeness of each document

The computed values of each subsection were multiplied by the subsection weights given by the experts and added to compute the accuracy/completeness of each document (DR/PR) under review.

$Document_i = SSweight_a . SS_a + SSweight_b . SS_b + \ldots . SSweight_n . SS_n$

$document_i$ - Accuracy/Completeness of i^{th} record DR/PR

$SSweight_a$ - Weight for $subsection_a$
$SSweight_b$ - Weight for $subsection_b$
$SSweight_n$ - Weight for $subsection_n$

Weights generated by expert responses to each subsection

SS_a - Value for $subsection_a$
SS_b - Value for $subsection_b$
SS_n - Value for $subsection_n$

Research findings

Calculation of accuracy/completeness of facility level one

The computed values of each document were multiplied by the document weights given by the experts and added to compute the accuracy/completeness of facility level one.

$S_{i\,(Total)} = Docweight1.Document1 + Docweight2.Document2$

$S_{i\,(Total)}$ – Total accuracy/completeness for a patient entry at facility level 1.

Docweight1 – Weight for the accuracy/ completeness of the DR
Docweight2- Weight for the accuracy/completeness of the PR

Weights by expert responses

Document1– Total accuracy/completeness of the DR
Document2 - Total accuracy/completeness of the PR

Values computed by formula.

$S_{i(Total\,(T))}$ - Last entry updated in both DR and patients register within one week after the management of the patient**.**

Calculation of data quality at facility level one,

The final data quality of facility level one was computed based on the values gained for accuracy, completeness, and timeliness according to above steps.

- $S_{dq(i)} = \beta_1 S_{iTotal(C)} + \beta_2 S_{iTotal(A)} + \beta_3 S_{iTotal(T)}$

$S_{dq(i)}$ - Score for data quality of i^{th} record

β_1 , β_2, β_3- Weight for each domain (Accuracy, Completeness, Timeliness) $_{i(Total\,(A)}$- Score for total accuracy

$S_{i(Total(C))}$- Score for total completeness

$S_{i(Total\,(T))}$- Score for total timeliness

RESULTS

Table one indicates that the three main subsections received equal weights for accuracy and completeness. The item treatment needs received the highest weight. Each item within the subsections scored over 0.8 for both accuracy and completeness.

Table 1: Weights for the main subsections and items in the PR

Main sub-Sections	Weight		Item	Weight	
	Accuracy	Completeness		Accuracy	Completeness
General Information	0.80	0.80	School Name	0.90	0.92
			Class	0.87	0.88
			Reg. No	0.88	0.90
			Child Name	0.88	0.90
			Date of Screening	0.87	0.88
Examination Finding	0.92	0.92	Treatment need	1.00	1.00
Care Provided	0.88	0.88	Treatment provided	0.85	0.85
			Treatment begun	0.85	0.85
			Treatment Completed	0.88	0.88

Table two shows that every subsection and item received a weight greater than 0.85. The care provided subsection had a perfect accuracy score of 1.00, and a completeness score of 0.97. The accuracy and completeness weights for the general information and examination finding subsections were comparable.

Table 2: Weights for the main subsections and items in the Daily Record

Main sub-Sections	Weight		Item	Weight	
	Accuracy	Completeness		Accuracy	Completeness
General Information	0.85	0.85	Reg. No	0.85	0.87
			Child Name	0.92	0.93
			School & Grade	0.88	0.88
			Consent	0.92	0.95
Examination Finding	0.98	0.98	Simple restoration Possible teeth	0.98	0.98
			Beyond Simple restoration teeth	0.93	0.93
			Missing teeth	0.95	0.97
			Filled teeth	0.98	0.96
			dmft/DMFT	0.98	0.90
			Gingivitis without Calculous	0.90	0.95
			Gingivitis with Calculous	0.95	0.87
			Dental fluorosis	0.87	0.95
			Malocclusion	0.95	0.93
			Other	0.93	0.88
Care Provided	1.00	0.97	Fluoride application	0.88	0.88
			Fissure sealant	0.88	0.88
			Temporary filling	0.93	0.93
			Amalgam filling	0.98	0.98
			GIC Filling	0.98	0.98
			Brushing demonstration	0.97	0.98
			Full Mouth scaling	0.93	0.98
			Referral	0.97	0.98
			Other treatment	0.87	0.87
			Treatment begun	0.88	0.90
			Treatment Completed	0.93	0.95

PR and DR were assigned equal relative importance with weights of 0.95 for accuracy and completeness. The final weighted average of data quality for facility level one was computed using the aforementioned formula, considering the weights assigned by the experts for the three primary domains of data quality.

Data quality = 0.95(Accuracy) + 0.95(completeness) + 0.93(Timeliness)

DISCUSSION

Due to the complex nature of data quality research in public health programmes, an in-depth literature review was done to understand the methods used in data quality studies, the dimensions used to measure the data quality and to identify the limitations of those studies. The proposed method was developed to address the limitations inherent to data quality studies discussed in the literature in a step-wise manner.

Key informant interviews were used when selecting the critical dimensions of data quality. The supporting literature confirmed that the most commonly used dimensions of data quality were completeness, accuracy and timeliness (Alipour & Ahmadi, 2017; Hong Chen *et al*., 2014; Sidi *et al*., 2012).

Many studies do not describe how data entry forms are selected, when multiple forms exist for data entry. Some studies have selected one form from numerous data collection forms (Perera, 1998), while others have reviewed all available forms (Jayasekara, 2006; Wijesekara, 2014). Consequently, gaining expert consensus on the selection of documents for this study minimized bias and provided a methodological justification.

It was also noted that data quality was dependent on the relative importance of the chosen variable (Wijesekara, 2002). Another study found that the degree of completeness varied depending on the desired number of data fields or variables included to measure data quality. If more variables were included as a measure of completeness, the level of completeness would be reduced (Alwhaibi *et al*., 2019). Moreover, it was also noted that many studies fail to explain the item selection process to measure data quality (Fernando, 2005; Fonseka, 1996; Jayasekara, 2006). We selected items based on their relative importance by calculating weighted averages to minimize the bias introduced due to the relative contribution of each element to the data quality. This also introduces a valid method to select the underline item structure that impacts the data quality.

In order to establish consensus on decisions regarding the data quality measurement method and minimize design bias, expert opinions were sought during the tool's development. The selection of items and computation of weights for calculating composite variables were determined via expert feedbacks, with the aim of validating the data quality method and operationalizing domains from a practical perspective.

To select relevant items and determine weights for items of interest, a sample of 18 experts representing academic, policy-making, administrative, and operational were chosen. A purposive sample was utilized to capture a detailed and diverse understanding of SDS. This approach is often employed by qualitative methodologists to gather cases that are rich in information (Patton, 2002; van Rijnsoever, 2017; Vasileiou, Barnett, Thorpe, & Young, 2018). Wijesekara adopted a similar technique to choose the items contained in the medical records in Sri Lanka (Wijesekara, 2014).

A rigorous process was followed in creating the assessment method and DQA checklist. Through the use of a panel of content experts, the validity of the DQA checklist and assessment method was established, given that it was a technical measuring tool. The feasibility of the DQA checklist was confirmed by pre-testing it. Finally, the tool and method were used to measure data quality at facility level one.

CONCLUSION

The proposed methodology for developing a tool and assessing data quality in public health programs could be applied as a guide in similar contexts. However, the research instrument, as developed and implemented in this study, does not include a thorough assessment of construct validity, criterion validity, and test-retest reliability. While the instrument was carefully designed and underwent initial pilot testing, these higher forms of validation and reliability were beyond the scope of this particular study.

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