Understanding latent structures of clinical information logistics: A bottom-up approach for model building and validating the workflow composite score

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**Abstract**

Background and purpose: Clinical information logistics is a construct that aims to describe and explain various phenomena of information provision to drive clinical processes. It can be measured by the workflow composite score, an aggregated indicator of the degree of IT support in clinical processes. This study primarily aimed to investigate the yet unknown empirical patterns constituting this construct. The second goal was to derive a data-driven weighting scheme for the constituents of the workflow composite score and to contrast this scheme with a literature based, top-down procedure. This approach should finally test the validity and robustness of the workflow composite score.

Methods: Based on secondary data from 183 German hospitals, a tiered factor analytic approach (confirmatory and subsequent exploratory factor analysis) was pursued. A weighting scheme, which was based on factor loadings obtained in the analyses, was put into practice.

Results: We were able to identify five statistically significant factors of clinical information logistics that accounted for 63% of the overall variance. These factors were “flow of data and information”, “mobility”, “clinical decision support and patient safety”, “electronic patient record” and “integration and distribution”. The system of weights derived from the factor loadings resulted in values for the workflow composite score that differed only slightly from the score values that had been previously published based on a top-down approach.

Conclusion: Our findings give insight into the internal composition of clinical information logistics both in terms of factors and weights. They also allowed us to propose a coherent model of clinical information logistics from a technical perspective that joins empirical findings with theoretical knowledge. Despite the new scheme of weights applied to the calculation of the workflow composite score, the score behaved robustly, which is yet another hint of its validity and therefore its usefulness.

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1. Background and significance

Providing accurate information, at the right time, in the right format and to the right actor is commonly described as the key aim and general definition of information logistics – an increasingly utilised construct among different research domains and industries [1,2]. Research on information logistics is strongly fragmented across various disciplines, as it is applied to multiple contexts for varying motivations. For example, it is being used to explain the local distribution of information, such as newspaper or radio, to increase productivity in information producing organisations (e.g. banks or insurance), or to increase efficiency in industrial production networks, such as the automotive industry [3]. Investigations within clinical contexts ("clinical information logistics") found potential application in process improvements – a crucial success factor of efficient IT support of clinical workflows [4,5]. Despite its use in multiple contexts and initiatives [2,4,6,7], information logistics is a rather young and poorly developed research domain, thus requiring more empirically founded investigations [3]. Research within clinical contexts [6,8] was often highly narrative and descriptive, pointing out basic aspects, benefits, and applications of clinical information logistics, yet rarely established an empirical methodology. Although process orientation, functions, data, integration, mobility and decision support were mentioned as key aspects [2,6],...
a comprehensive model is absent, Haftor and colleagues, therefore, concluded that the lack of a comprehensive approach and sound methodology leads to unjustified results [3]. Thus, underlying structures of “good” information logistics in the context of clinical processes are largely unknown while its increasing significance has been emphasised [9].

First attempts to address this gap were made by Liebe and colleagues [5] who followed a theory driven top-down approach based on relevant literature and expert discussions. This led to a framework, in which the construct “clinical information logistics” was subdivided into four basic components, referred to as descriptors:

1) “Data and information” as the basic requirement to perform tasks in the respective workflow (e.g. patient demographics, results (text, images & electrophysiology), medication, vital signs etc.).

2) “Functions” and IT applications that provide, process and store data for further use (e.g. clinical decision support systems (CDSS), computerised physician order entry (CPOE), electronic nursing record etc.).

3) “Integration” to allow interoperability between these functions and IT applications (e.g. hospital information system integration architecture, way of transferring patient data between systems etc.).

4) “Distribution” to describe the ability of disseminating data, information and functions to different points of care within or outside the own institution (access to data, available devices for use, mobility of data and applications, Wi-Fi-coverage, etc.).

The resulting framework was put into practice within a procedure for evaluating and benchmarking IT support of clinical workflows in German hospitals [10]. The workflows selected were required to be part of the core processes of hospitals and had to be sufficiently complex, including multiple professions, departments and institutions to ensure that they were qualified to represent the comprehensive scope of clinical information logistics [11]. Following these criteria, the four workflows “ward round”, “pre-surgery care process”, “post-surgery care process” and “discharge” were identified as most suitable [5].

Combining these four workflows with the four descriptors led to a 16-cell matrix, from which the relevant IT features were derived and corresponding items, i.e. questions, for the IT Report Healthcare survey 2013 [12] were developed. This linkage allowed the construction of a three-level hierarchy of key performance indicators (Fig. 1). Level 3 contained detailed features (level 3.2) and more general items (level 3.1) from the survey. They were then aggregated in the descriptors for each of the processes (level 2) and ultimately merged in the so called workflow composite score (WCS, level 1), an overall measure of clinical IT workflow support on the theoretical foundations of information logistics. The WCS was proposed as a globally applicable instrument due to its foundation on the international literature and its validation with EHR concepts used worldwide [5].

Unpacking clinical information logistics into the four descriptors presented above was realised by a theoretically driven top-down approach [5]. Largely following the literature (e.g. Jha and colleagues [13]), the conceptualisation of clinical information logistics was independent of the underlying empirical data. Even though this approach led to a comprehensive classification scheme that ultimately produced valid and predominantly reliable results, retrospective and data driven bottom-up attempts to further investigate and validate the measurement of clinical information logistics were still required [5]. In detail, there is a need for empirically testing the convergent and discriminant construct validity of clinical information logistics. This need is also stressed in the OECD “Handbook on Constructing Composite Indicators” [14], where applying multivariate analysis techniques is described as an integral part when developing composite scores in order to assess and evaluate the underlying data structure. Resulting insights from these analyses can then be synchronised with existing theoretical conceptions, strengthening the construct’s theoretical understanding.

An important issue, hereby, is to empirically analyse underlying factors of clinical information logistics and evaluate to what extent these latent structures influence the construct. For this purpose, the descriptors pose a reasonable starting point since they already provide a systematic cluster. Having in mind that descriptors are rather to be seen as generic clusters to sort a comprehensive entity, it is justifiable to assume that they may have similar attributes to statistical factors, which in contrast aim to describe the inner texture of the construct. Furthermore, reliability testing of the descriptors revealed insufficient values for “integration” and “distribution” [5], which again encourages further investigation. Aside from this, the current items and features constituting the WCS are essentially equally weighted due to a lack of an alternative model. An empirically justified weighting procedure that accentuates important domains and suppresses the influence of negligible content is not only desirable for getting a better balanced score [14] but also helps to assess the robustness and sensitivity of the WCS against manipulations in its construction.

Similar studies demonstrate successful application of factor analytic approaches in conjunction with conceptualising and measurement of IT adoption [15–17], for building composite scores [18,19] as well as to test for construct validity of abstract phenomena [2,20]. However, to our knowledge there are no studies explicitly focussing on clinical information logistics.

![Fig. 1. WCS levels of hierarchy.](image-url)
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