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Development and initial validation of a content taxonomy for patient records in general dentistry

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Abstract

Objective—Develop and validate an initial content taxonomy for patient records in general dentistry.

Methods—Phase 1–Obtain 95 de-identified patient records from 11 general dentists in the United States. Phase 2–Extract individual data fields (information items), both explicit (labeled) and implicit (unlabeled), from records, and organize into categories mirroring original field context. Phase 3–Refine raw list of information items by eliminating duplicates/redundancies and focusing on general dentistry. Phase 4–Validate all items regarding inclusion and importance using a two-round Delphi study with a panel of 22 general dentists active in clinical practice, education, and research.

Results—Analysis of 76 patient records from 9 dentists, combined with previous work, yielded a raw list of 1,509 information items. Refinement reduced this list to 1,107 items, subsequently rated by the Delphi panel. The final model contained 870 items, with 761 (88%) rated as mandatory. In Round 1, 95% (825) of the final items were accepted, in Round 2 the remaining 5% (45). Only 45 items on the initial list were rejected and 192 (or 17%) remained equivocal.

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Authors' contributions

Amit Acharya (Main author): Designing and conducting the study, analyzing and interpreting the data, drafting the article and revising it critically for important intellectual content.
Pedro Hernandez: Analyzing and interpreting the data.
Thankam Thyvalikakath: Designing the study, drafting the article and revising it critically for important intellectual content.
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Conclusion—Grounded in the reality of clinical practice, our proposed content taxonomy represents a significant advance over existing guidelines and standards by providing a granular and comprehensive information representation for general dental patient records. It offers a significant foundational asset for implementing an interoperable health information technology infrastructure for general dentistry.

Keywords

Dental Informatics; Delphi Technique; Dental Records/standards; Dentists' Practice Patterns/standards; Information Management; Information Storage and Retrieval

1. Introduction

The American Dental Association (ADA) defines the dental patient record as "the official office document that records all diagnostic information, clinical notes, treatment performed, and patient-related communications that occur in the dental office, including instructions for home care and consent to treatment [1]." As in medicine, dental professionals are required to maintain accurate and complete patient information in these records [2]. As expressed by the adage "dentists and patients forget but good records remember" complete and comprehensive patient, records are essential to support decision-making processes and perform outcomes research [3]. However, current evidence suggests that dental records vary significantly in the degree to which they meet this standard and in some cases may be inadequate [4,5]. Structured record cards or computerized recordkeeping systems that guide the dentist through the examination in a logical manner may help improve recordkeeping [6]. As more and more dentists adopt electronic dental records to deliver patient care [7], it is essential that we address the question of what patient information should be documented and how it should be structured [8].

During the last three decades, state, national, and international dental organizations have produced guidelines and/or standards for essential components of the dental record. Among them are 'Guidelines for Criteria and Standards of Acceptable Quality General Dental Practice' developed by Shoen et al. In 1989 [9], minimum recordkeeping standards for patient records developed by the Minnesota State Board of Dentistry in 1997 [10], 'The Dental Patient Record: Structure and Function Guidelines' developed by the American Dental Association (ADA) in 1987 [11], guidelines on content of clinical records developed by the Faculty of General Dental Practitioners (UK) [12], and criteria for characteristics, format, and content of a quality dental record developed by the Wisconsin Dental Association (WDA) Council on Dental Care [13]. Common information categories recommended in these guidelines include personal/demographic information, reason for visit, dental history, medical history, clinical examination information, diagnosis, treatment plan and informed consent information. Beyond these association-based efforts, the ADA's Standards Committee on Dental Informatics (SCDI) has completed significant work on three major standards for electronic health records (EHR) content: the ANSI/ADA Specification No. 1000: Standard Clinical Data Architecture for the Structure and Content of an Electronic Health Record [14]; ANSI/ADA Specification No. 1039: Standard Clinical Conceptual Data Model [15]; and ANSI/ADA Specification No. 1040: Dental Extension to the Continuity of Care Record [16]. However, none of these guidelines describe information categories and data fields in the general dental record in a comprehensive and granular manner. Along with the above guidelines and standards to represent the content of data fields that should be in the patient records, there are several standardized terminology sets available to represent the content of values these data fields can hold. Some of such terminology sets that are applicable to dentistry are Systematized Nomenclature of Dentistry (SNODENT) [17–19].

Several studies have suggested that dental records vary significantly in the degree to which they meet existing guidelines. Hand and Reynolds [20] audited 316 dental records from 13 facilities in New York State for the presence and adequacy of 13 data elements. Not only were more than 50% of facilities unable to present all requested records for the initial audit, but the examined records showed significant deficiencies. Over 22% of patient records had at least four deficient elements, while only 19.3% contained all elements. Beyond deficiencies common in dental records, dentists' perceptions of record adequacy appear to be at odds with published recommendations. As Table 1 shows, respondents from a study by Osborn et al. [21] who rated their patient records as adequate did not record important clinical information in 21.3% to 39.3% of their records. Respondents who rated their patient records as inadequate had even higher deficiencies, ranging from 39.4% to 58.3%. Similar observations were made in an earlier study of Florida dentists conducted by Minden [22]. A study performed by the WDA found that dentists created their own recordkeeping systems, resulting in a lack of uniformity in patient records maintained by dentists [13]. Inadequate documentation in dental records has not only been found in the United States, but also in the United Kingdom [23], Australia [24], and Scandinavia [25–28]. Several studies have stressed the need for implementation and further development of guidelines for information in an electronic dental record (EDR) [21,22].

The rapidly increasing adoption of EDRs by practicing dentists [7] means that we are about to translate our paper-based "Tower of Babel" of patient records to an electronic one, leaving many potential benefits of EDRs unattained. Electronic records could help make the type of patient record quality assurance studies described above both easier and more commonplace than they are now. They could facilitate patient-centered collaborative care [29], address oral-systemic connections [30], make the healthcare system more efficient [31–35], and support reuse of patient data for research [36,37]. A study conducted by the Center for Dental Informatics at University of Pittsburgh in 2005–2006 showed that 25% of U.S. general practitioners used a computer at chairside and 1.8% were completely paperless [38]; these figures had grown to 55.5% and 9.2%, respectively, in a 2006–2007 survey of dentists conducted by the ADA [39]. A 2010 survey of California dentists [40] showed that 23% had implemented a fully electronic dental record in their practice, as had 15.9% of solo practitioners in a recent survey by the Dental Practice-based Research Network [7].

Preceding the current study, we conducted the, to date, most detailed analysis of dental patient record formats in 2007 [41]. In that study, we analyzed the data fields of ten paper- and four computer-based patient record formats, resulting in a categorized list of 363 distinct data fields, which we called the Baseline Dental Record (BDR). The study revealed a large variation in the structure and content of both paper and computer-based dental records.

In 2010, we conducted a pilot to evaluate the feasibility of defining new patient record data fields from the content of 10 de-identified patient dental records [42] based on the framework of the BDR. We added 134 data fields, resulting in a categorized list of 497 distinct data fields [42]. Building on our previous results, we took the analysis and definition of dental patient record content one step further in this study. Our purpose was to define and validate a content taxonomy of data fields for patient records in general dentistry by analyzing de-identified patient records within the framework of our previous studies. To validate this taxonomy in light of actual practice, we performed a Delphi study with a panel of general dentists active in clinical care, research, and education.

2. Methods

Our study had four phases (see Fig. 1). In Phase 1, we obtained 95 de-identified patient dental records from a purposive sample of 11 general dentists in the United States. In Phase

2, we extracted individual data fields (henceforth called *information items*) from these records and organized them into logical categories to form a candidate list of information items. In Phase 3, we refined the candidate list of information items by eliminating duplicates/redundancies and focusing it on general dentistry. In Phase 4, we recruited a panel of 22 general dentists (practitioners, researchers, and educators) to rate each item on whether it should be retained in the list, and, if so, whether it should be mandatory or optional.

2.1. Phase 1: Obtain de-identified patient dental records

Our sampling strategy was designed to maximize the diversity of dental records in order to generate the broadest possible set of dental information items. First, we purposively selected 11 general dentists actively practicing and geographically distributed across the United States. Then, we asked each participant to provide ten patient records at three different levels of complexity (simple, medium and complex), de-identified according to the HIPAA Safe Harbor method [43]. Simple cases were patients without systemic disease who had between one and five treatment procedures of one type of dental treatment, such as restorative and periodontal therapy. Medium cases had no systemic disease, and six to ten procedures of two or more types of dental treatment. Complex cases were patients with or without systemic disease who had more than ten procedures of three or more types of dental treatment. Additional inclusion criteria were: records had to be from active patients, written in English, and have at least one finding (e.g. "*cavitation m #13*") and/or one diagnosis (e.g. "*generalized periodontitis*"). We asked each dentist to send copies of two simple, four medium, and four complex cases.

2.2. Phase 2: Extract and organize a candidate list of information items

We used the 497 categorized information items from our pilot study [42] as the basic taxonomy for the documented patient information in the reviewed dental records. We then extracted information items from the dental records according to the methodology developed in our earlier study [42]. Two dentists trained in dental informatics (AA, PH; henceforth known as reviewers) extracted data contained in the records into a comprehensive candidate list of information items. The reviewers identified all the information items from the records through face to face discussion and consensus agreement. Information items were discovered in two ways. *Explicit* items were labeled data fields, such as *Reason for visit* in Fig. 2. *Implicit* items were information items that were not labeled but were clinically distinguishable concepts, such as *Systolic blood pressure* and *Diastolic blood pressure*, implied in the recorded datum *130/68 mm of hg*. If an extracted information item already existed in the candidate list, it was coded as being present and was not added, otherwise it was added. We excluded *Patient data values* (see Fig. 2).

In adding individual information items to our growing candidate list, we attempted to stay as close as possible to the original structure and context they were embedded in (see Fig. 2). Since the BDR was constructed from patient record forms, its structure mirrored the native organization of patient records. If possible, we added new items to that structure in ways that corresponded to the original context they were found in. In some instances, the reviewers added/changed information categories in the candidate list to create logical groupings for extracted information items. For example, *Blood Pressure* was defined as a new information category with *Systolic Blood Pressure* and *Diastolic Blood Pressure* as the implicit information items and *Patient position while recording blood pressure* and *Base line blood pressure* as explicit information items within it. Reviewers also reorganized several information categories by splitting or renaming the categories in clinically meaningful ways. For example, the initial list from the pilot study contained the top level information category *Dental/Social History* with the children *Dental history*, *Social history,* and *Pain*. We split

Dental/Social history into *Comprehensive oral history* and *Social history*. The child categories *General dental health*, *Previous dental visit*, *Previous dental care*, *Homecare regimes*, *Past and present dental problems* and *Parafunctional habits* were then assigned to the *Comprehensive oral history* category.

2.3. Phase 3: Refine the information item list

Subsequently, a panel of four dentists (AA, PH, TT, TS) refined the candidate list of information items to: (1) eliminate any redundant information items occurring in multiple information categories; (2) limit the scope of the candidate list to represent general dentistry; and (3) add, change, and/or delete information categories to improve the logical grouping of information items. To make these refinements, the panel met over a course of four 3-hour workgroup meetings.

2.4. Phase 4: Rate candidate information items through a Delphi process

The purpose of Phase 4 was to obtain consensus on the information items most appropriate for a general dental record from an external expert panel of general dental clinicians who were active in clinical care, research, and education. We conducted a modified, two-round Delphi study [44] because its iterative approach delivers both qualitative and quantitative results, and subsequent rounds are informed by the results of each previous one [44]. The Delphi method overcomes some of the disadvantages of the committee process because it is anonymous, but at the same time offers controlled review and feedback [45]. Also, the level of agreement is quantifiable by statistical methods [46].

2.4.1. Participant recruitment—Since the focus of this study was to develop a list of information items most appropriate for general dentistry, all panel members were general dentists with DMD/DDS/BDS degrees with primary occupation as private practitioners, educators and researchers. We expected responses to reflect each group's respective background, context, and priorities. Delphi study panel members were identified through purposive sampling from lists provided by the American Dental Association's Standards Committee for Dental Informatics and the American Dental Education Association. While there is little empirical evidence on the effect of the number of participants on reliability or validity of consensus processes, 10 to 15 participants are considered adequate for focused studies involving a homogeneous set of participants [47]. A group of 42 participants was recruited to the panel to handle any attrition during the Delphi voting process.

2.4.2. Voting process—In Round 1, the 42 panel members were randomly divided into 3 balanced subgroups of 14 participants and the list of information items was divided into 3 cohesive sections. To statistically control for ordering effects, we assigned sections to each subgroup in a different order, and used t-tests to compare ratings among the three subgroups, and between the group of practitioners and the combined group of educators and researchers.

Panel members received the list of information items in an Excel spreadsheet with built-in macros, allowing them to rate each item as shown in Fig. 3. Spreadsheets were developed and pilot-tested for ease of use and any navigability issues by AA and TS. Panel members were allotted a 4-week time period to rate each sublist. We sent two email reminders to panel members during each iteration, one after the 2nd week and one after the 3rd week.

Panel members voted on whether to retain each information item as part of a general dental record format using a 5 point Likert scale: 1–strong disagreement, 2–disagreement, 3–neutral, 4–agreement and 5–strong agreement. Panel members also classified retained information items as 'mandatory' or 'optional' with the scale 'agreement' or 'strong

agreement.' They also had the. opportunity to modify existing information items and/or add any missing information items. Modified and new items were included in the subsequent Delphi round.

After all information items were reviewed and voted on in Round 1, mean scores were calculated, as well as the 95% confidence interval (CI), for each information item. Based on previously published work [48–51], we examined the lower and upper limits of the 95% CIs, and classified each information item into one of three categories: (1) retained information items–those with a score with a lower-limit 95% CI of ≥3.5, indicating consensus agreement, (2) rejected information items–those with a score with an upper-limit 95% CI of ≤3.0, indicating consensus disagreement, and (3) equivocal information items–those with a score with a lower-limit 95% CI <3.5 and upper-limit 95% CI >3.0, indicating the need for reevaluation.

Retained and rejected information items were not included in Round 2. For each equivocal information item, panel members were provided with their individual score and the mean group score from Round 1 to aid in the consensus-building process. After Round 2, information items were again classified as retained, rejected and equivocal as previously described. Both rejected and equivocal information items were excluded from the final taxonomy.

The missing data problem was handled by averaging the data provided by the rest of the panel members for analysis. Each retained information item was classified as either mandatory or optional by calculating the mode of all recorded values.

The study was classified as "exempt" under section 45 CFR 46.101(b)(2) by the Institutional Review Board at the University of Pittsburgh (IRB# PRO07100260).

3. Results

The outcomes of the study by phase are summarized in Fig. 1 and reported below.

3.1. Phase 1: Obtain de-identified patient records

De -identified dental records solicited in Phase 1 came from 11 general dentists in private practice in Connecticut, Florida, Illinois, Massachusetts, New Hampshire, Oregon, and Pennsylvania. Of the total of 95 de-identified patient records received for analysis, 30 were computer-based and 65 paper-based.

3.2. Phase 2: Extract and organize information items

At the end of the information extraction phase, we had extracted a total of 1,012 information items from 76 records. Fig. 4 shows the number of new information items extracted successively from each set of dental records. Since a sample of records from dentists #10 and #11 did not produce any new information items, we stopped the information extraction process after 76 records (20 computer-based and 56 paper-based). Together with the 363 information items in the BDR [41] and 134 information items collected in the pilot study [42], the number of items in the candidate list at the end of Phase 2 totaled 1,509.

3.3. Phase 3: Refine information item list

Eliminating duplicates/redundancies and focusing on general dentistry reduced the list to 1,107 information items. For example, we consolidated several information items present in multiple places in the list, such as *information recorded date, information updated date, location, causative factors, severity, size, surface, type*, *amount* and *direction*. The final list contained 1,107 information items in 177 information categories (21 top level categories)

with a hierarchy maximally 4 levels deep. For example, information categories like *Alert* and *Chief Complaint* had just one level, while *Comprehensive Health History* and *Comprehensive Oral History* had four.

3.4. Phase 4: Validate through Delphi study

The comprehensive candidate list of information items developed in Phase 3 served as the input for the Delphi voting process. At the end of Delphi Round 1, 22 panel members had completed the rating process within the allotted time period, for a response rate of 52%. Of the 22 respondents, 10 were general practitioners, 3 dental educators, and 9 dental researchers. Seventeen respondents were male and five female. The average age of panel members was 45.8 years (ranging from 29 years to 62 years), with average experience of 19 years as a general dentist. All panel members who completed Round 1 also completed Round 2.

Table 2 shows a summary of the Delphi study results conducted in Phase 4. Of the 1,107 information items rated by the Delphi panel, a total of 870 items (78%) were retained, 45 (4%) were rejected and 192 (17%) did not result in consensus. Only 14 new information items were suggested by the expert panel. The overwhelming majority of items, 825 (74.5%), was retained in Round 1. There were 262 equivocal items (23.6%) that were re-rated in Round 2. Only a small portion of items (20 or 1.9%) was rejected in the first round.

In Round 2, we distributed the 276 items (262 equivocal items + 14 new items) in a single spreadsheet to the raters. Round 2 showed that the panel could not come to consensus on 206 equivocal items (75%), while 45 items (16%) were retained and 25 (9%) rejected. We excluded the equivocal items from the final list of 870 information items. Of those, the panel considered 761 mandatory and 109 optional. Of the 870 information items, 752 were unique and 72 occurred in at least two information categories. 61 of the 72 information items that occurred in multiple places just occurred twice. *Tooth number*, *Anatomic location,* and *Tooth surface* occurred 15, 13 and 13 times, respectively, in various information categories and represented the top three most commonly occurring information items in the final taxonomy.

Table 3 shows comparisons in ratings between the practitioners versus the educators and researchers combined and the three balanced subgroups of Round 1. Only a small proportion of information items, ranging from 0.8 to 4.8%, was rated significantly different ($p<0.05$) between the three subgroups in Round 1. Among all subgroups, the proportion of items rated differently ranged from 0.9 to 2.9%. Since the three sets of data elements were administered in a different order to each subgroup during Round 1, ordering and/or fatigue effects are not evident from the data.

The comparison between the practitioners and the combined group of educators and researchers showed more marked differences than that for the subgroups individually. The two groups rated a total of 120 (10.8 %) information items significantly different ($p<0.05$). For 18 of these items, the p-value for the difference was <0.01: *steroids, bruxism appliance, night guard, flossing frequency, gag reflex, bleach allergies, chemical allergies, rheumatic fever, rheumatic heart disease, mononucleosis, stomach disorders, ulcerative colitis, hemophilia, sickle cell anemia, old amalgam presence, attached gingival tissues condition, procedure initiation date*, and *progress notes type*.

Table 4 and Table 5 show the 50 highest scored, retained information items, as well as the list of rejected information items. Highly scored items include information that is of immediate and/or general interest to practitioners, such as *chief complaint, presence of pain* and *medical alerts*. Highly scored medical conditions include *allergies, angina,*

cardiovascular disorders, diabetes, and *hepatitis*, as well as *physician care* and *changes in health history*. Other important items were related to medications and medication allergies. Additionally, items related to restorative dentistry (e.g., *presence of caries*, *existing and defective restorations*, and *open margins*) and periodontal status (e.g., *periodontal disease classification*, *plaque, pocket depth, furcation involvement* and *gingival bleeding*) were rated highly.

The most emphatically rejected items were related mainly to psychological/attitudinal findings about the patient, such as *aggressiveness*, *difficulty concentrating*, *feelings of inadequacy*, *incompetency* and *sadness*, as well as information related to radiograph exposure, such as *exposure time*, *kilovoltage peak* and *milliamperage*.

Table 6 provides an overview of the final information items categorized into 21 top-level categories and 36 second-level categories.

4. Discussion

The purpose of this study was two-fold: first, to define a list of information items that represent the most common content of general dental records by analyzing de-identified patient records sampled from private practitioners in the United States and second, to validate this list using a Delphi panel composed of general dentists active in private practice, research and education. We believe that our study has yielded a useful, clinically relevant, and valid initial content taxonomy for patient records in general dentistry for several reasons. Our study has produced a significantly more granular and comprehensive representation of dental record content than available in existing guidelines [9–13] and standards [14–16]. Existing recommendations only suggest minimum standards for dental recordkeeping and define general frameworks that practitioners can imbue with the desired level of detail. Our study, on the other hand, has produced a detailed, well-structured, and granular taxonomy for dental record content. It did so by combining the strengths of complementary bottom-up and top-down approaches. By constructing patient record content from authentic source documents (patient record formats and, in this study, de-identified, completed patient records), we ensured that our taxonomy is firmly grounded in the realities of clinical practice. The top-down review by a diversified panel of general dentists ensured that our taxonomy met the needs of various aspects of general dentistry. This approach makes our taxonomy more likely to be adopted than other guidelines and standards, which are typically developed top-down in relative isolation from actual practice.

Convergence on a core set of data elements for general dentistry occurred fairly rapidly both in the construction of the taxonomy as well as its validation. As Fig. 4 shows, it took only 76 patient records from nine practitioners to reach saturation in terms of discovering new information items. While records from additional dentists may have produced new information items, the marginal gains of doing so would likely have been small given the early stage of development of this taxonomy. At the same time, the Delphi panel accepted 95% (825) of the final items in Round 1 and the remaining ones (5% or 45 items) in Round 2. In addition, the panel considered 761 (88%) of the information items to be mandatory. The Delphi panel's response rate (52% in Round 1 and 100% in Round 2) is evidence for member engagement and a commitment to reach true consensus, especially in light of the significant effort required to rate the over 1,100 information items. These results constitute strong evidence for consensus on the core elements of the record. We therefore believe our study satisfied the goal of identifying the *most common* information items for general dental records.

At the same time, our candidate list clearly contained information items that were considered not very or not at all central to general dental practice. The panel rejected 45 (or

4%) of the information items, which appear to have only a tenuous connection to general dental practice. The fact that the panel did not reach consensus on 192 (or 17%) of the items indicates that there is a “gray area” that should be further examined.

Based on our previous work [41], the average number of clinical information items in the four market-leading electronic dental records is significantly lower than in our content taxonomy. However, since our taxonomy is a composite of many different recordkeeping systems, it serves mainly as “reference” taxonomy for the design of real systems. We expect that system developers will subset data fields from the content taxonomy to serve their specific purposes.

It could be argued that some of the information items in our content taxonomy could look like data values and hence should be in a terminology sets. This is a classic problem that arises when achieving semantic interoperability where there is a need to define three distinct models (information, terminology and inferencing model) and its content [52]. An example of a very simple information model would be a model called *Conditions* which is complemented by a terminology model containing values such as ‘Diabetes’, ‘Asthma’, ‘Rheumatoid arthritis’, ‘Caries’ and ‘Periodontal disease’. Conversely, the simplest terminology model could consist of just ‘Yes’ and ‘No’ and would be combined with an information model including information items such as *Diabetes, Asthma, Rheumatoid arthritis, Caries and Periodontal disease*. Our taxonomy mirrors the way that information items are organized on patient dental record forms that are used in daily practical use, however, where to draw the line between the information and terminology models is at the discretion of system developers.

Limitations

This study has a number of limitations. First, while our purposive sample of patient records was intended to maximize patient record diversity, it came from a relatively small group of practitioners, and thus may not be entirely reflective of dentists’ record-keeping practices at large. Second, the relevance of items was assessed only through the Delphi panel, and other factors, such as frequency of use in source records, and inclusion in textbooks and teaching materials, were not taken into account. Third, 11% of the items were scored significantly differently by the group of practitioners and the combined group of educators and researchers. This finding shows that the taxonomy may not meet all information needs of dental researchers and educators. Last, acquiring and analyzing data values for the data fields would likely have enhanced our content taxonomy, doing so was outside the scope of our study. To include data values in a meaningful way, we would have had to collect and analyze all (or most) commonly used data values for each data field. This would have required a much more sophisticated and comprehensive sampling strategy and analytical approach than we used in the study.

Future work

Our content taxonomy is a rich contribution towards developing a standard information model for general dentistry. Converted to a formal model for representing dental information, our work could serve multiple purposes in the future, such as database and user interface design, data exchange among systems, creation of longitudinal patient records, and reuse of data for quality assurance and research. Our work could be used to augment and extend existing data representation standards in dentistry, such as ANSI/ADA Specifications Nos. 1000, 1039 and 1040 [14–16], especially when formulated as an information model [8]. In the future, our taxonomy should be evaluated regarding its suitability for data representation in the context of patient care in field studies. Additionally, the model should be extended to meet the needs of clinical specialists, researchers, and educators.

5. Conclusion

Our proposed content taxonomy represents a significant advance over existing guidelines and standards by providing a granular and comprehensive information representation for general dental patient records. Grounded in the reality of clinical practice, our taxonomy adds important levels of granularity and detail in representing patient data that have not been available to date. It offers a significant foundational asset for implementing an interoperable health information technology infrastructure for general dentistry, as envisioned for all of healthcare [53].

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Summary Points

What was already known on the topic

- There is no broad agreement among dentists, dental educators, and researchers on what information dental records should contain in detail and how they should be structured.
- The implementation of interoperable health records in the US requires dentistry to move away from an idiosyncratic, highly practitioner-specific recordkeeping approach to one that is more systematic and standardized.

What this study added to our knowledge

- The study adds significant detail to the work on dental record guidelines and informatics standards in dentistry, which currently only provide general guidance for dental recordkeeping.
- The list of data fields in the proposed taxonomy has received preliminary validation through a Delphi panel of general dentists active in clinical practice, research and education.

Strengths and Limitations of this Study

- Converted to a formal model for representing dental information, our work could serve multiple purposes in the future, such as database and user interface design, data exchange among systems, creation of longitudinal patient records, and reuse of data for quality assurance and research.
- While our sample of patient records was intended to maximize record diversity, it came from a relatively small group of practitioners, and may not be entirely reflective of dentists' record-keeping practices at large.

Research Highlights

- There is no broad agreement among dentists on components of dental records.
- We provide detail to the work on dental record guidelines and informatics standards in dentistry.
- Our proposed list of data fields has been validated through a Delphi panel of dental practitioners.

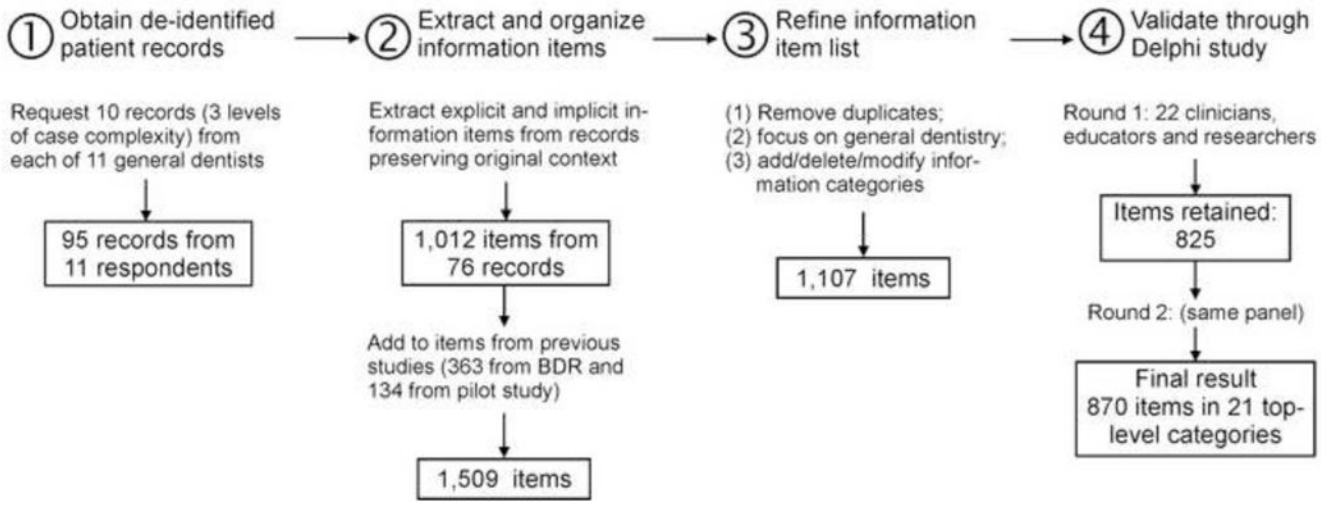

Fig. 1.
Flow diagram depicting the four phases of the study (BDR=Baseline Dental Record)

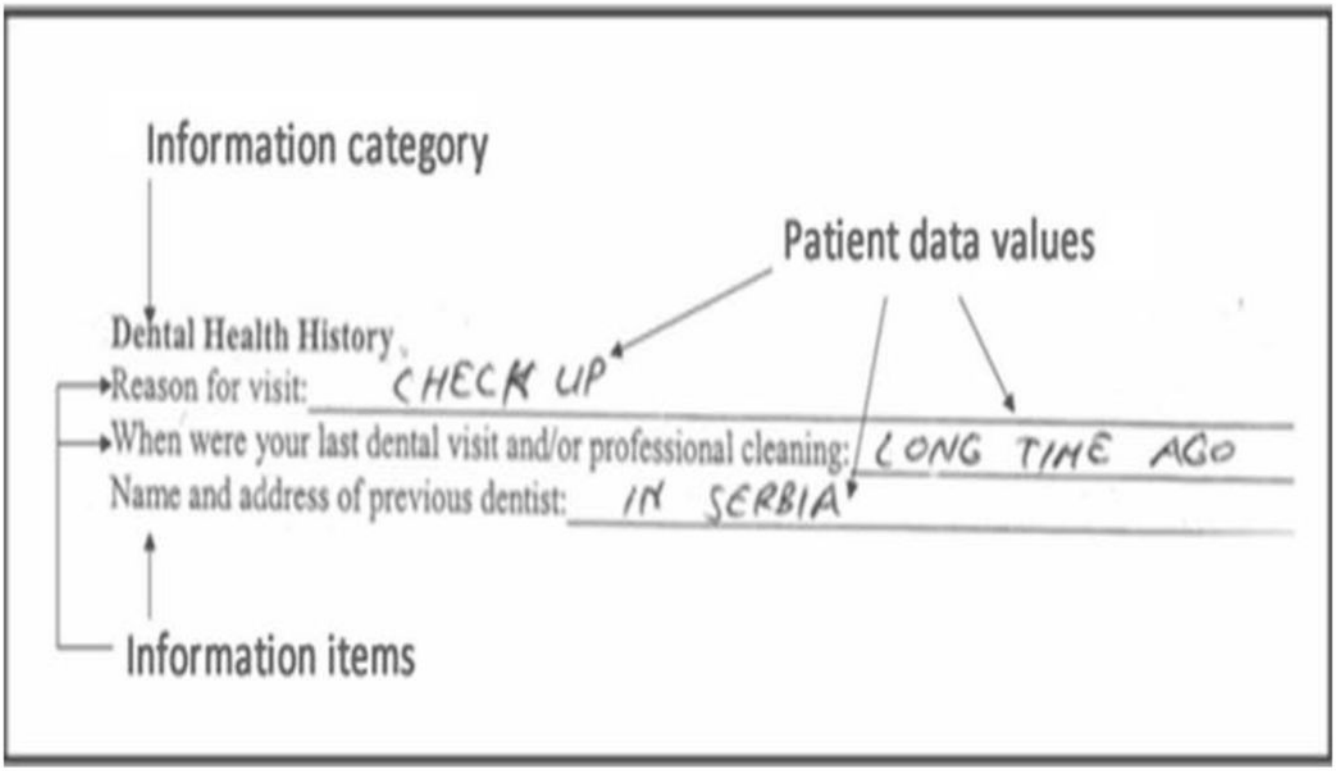

Fig. 2.
Example of the information category "Dental Health History" with information items and patient data values from a dental patient record reviewed to generate a list of information items in general dental records

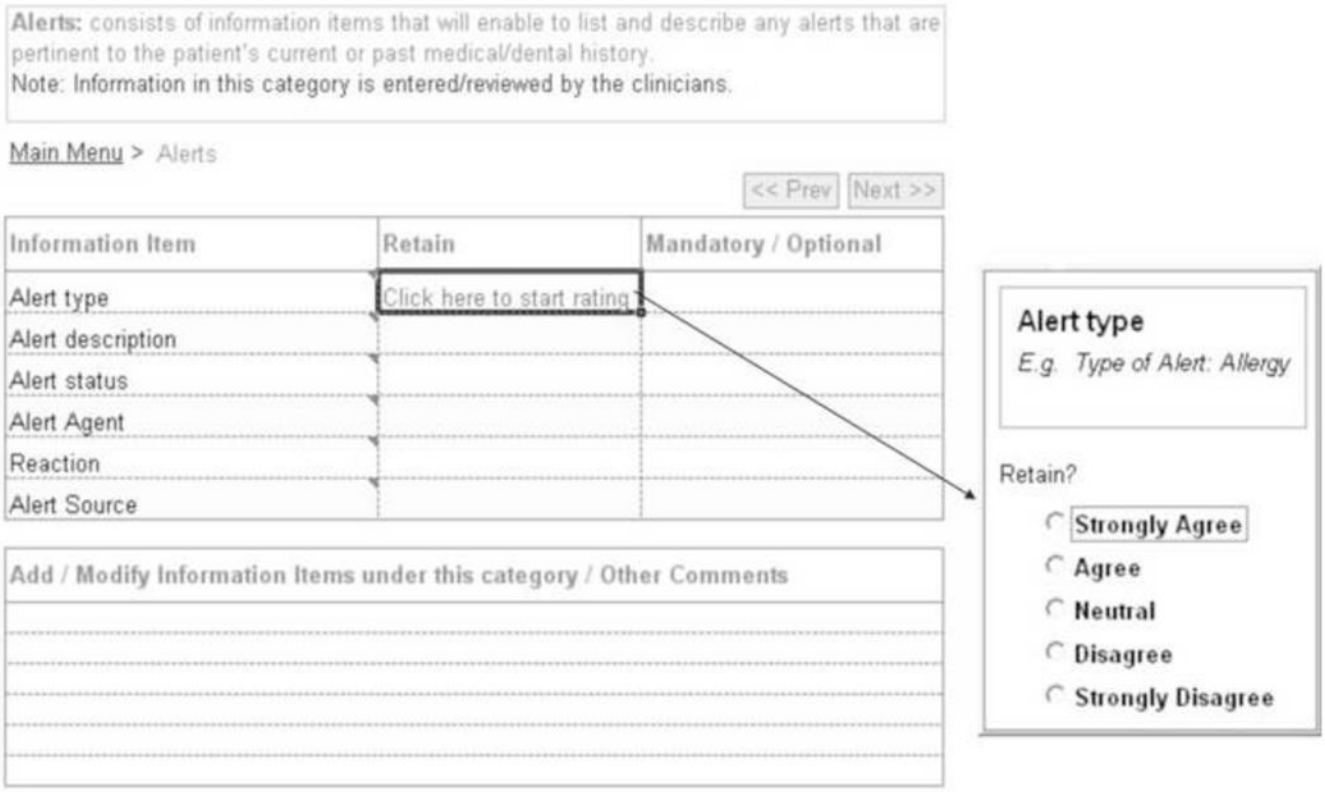

Fig. 3.

Sample rating form for the information category "Alerts" in Delphi Round 1. The rating form included a description of the information category at the top and a list of information items. Panel members rated each item on the 5-point scale shown on the right and could add/modify items as appropriate. In Round 2, the form included the panel's average rating for each item, as well as the panelist's previous rating.

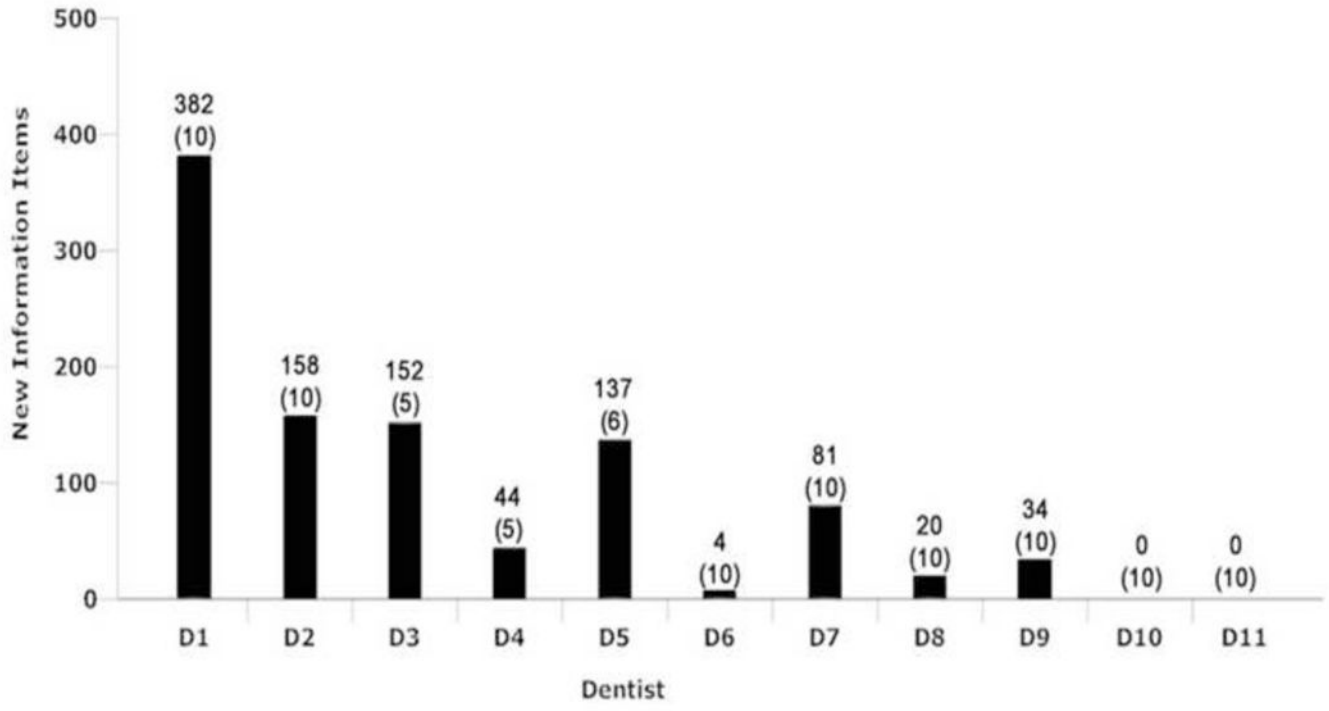

Fig. 4.

Number of new information items extracted from each set of de-identified dental records obtained from nine dentists (number of records from each dentist in parentheses); total number of information items generated through record review: 1,012.

Table 1

Snapshot of different clinical information not recorded by Dentists who perceived their documentation to be adequate and inadequate from Osborn et al. [18]

Dentists who perceived their documentation to be:	Medication Dosage		Relevant Family History		Dental Phobias		Last Dental Visit	
	%	N	%	N	%	N	%	N
Adequate (Total = 403)	39.3	156	24.6	94	38.2	145	21.3	82
Inadequate (Total = 72)	58.3	42	35.7	25	51.4	36	39.4	28

Table 2

Results from Delphi Round

Category	Total		Round 1 Detail		Round 2 Detail	
	N	%	N	%	N	%
Retained	870	78.0	825	74.5	45	16.0
Rejected	45	4.0	20	1.9	25	9.0
Equivocal	192	17.0	262	23.6	206	75.0
Items Added	14	1.0	14	n/a	none	n/a
Total	1,121	100.0				

Table 3

Comparison of the differences in voting among different groups in Round 1 using t-test analysis

	List 1 (N = 385)		List 2 (N=329)		List 3 (N=393)		Total Items (N=1107)	
	# of items with sig. diff (P<0.05)	%	# of items with sig. diff (P<0.05)	%	# of items with sig. diff (P<0.05)	%	# of items with sig. diff (P<0.05)	%
Sub group 1 vs. Sub group 2	4	1.0	3	0.9	3	0.8	10	0.9
Sub group 1 vs. Sub group 3	3	0.8	10	3.0	19	4.8	32	2.9
Sub group 2 vs. Sub group 3	0	0.0	3	0.9	11	2.8	14	1.3
Practitioners vs. Educators and Researchers	38	9.9	43	13.1	39	9.9	120	10.8

Table 4

List of top 50 accepted information items after Round 1 of the Delphi study (sorted alphabetically)

Information Items	Mean	Standard Deviation
AIDS/HIV status	4.8	0.43
Alert description	5.0	0.22
Allergies	4.9	0.43
Anesthetic name	4.8	0.40
Angina	4.8	0.43
Bleeding disorder	4.8	0.46
Blood disorders	4.8	0.43
Bone loss	4.8	0.40
Calculus	4.8	0.40
Cancer	4.8	0.40
Cancer Therapy	4.8	0.43
Cardiovascular disorder	4.9	0.55
Change in health history	4.9	0.29
Chief complaint	5.0	0.22
Defective margins	4.8	0.40
Defective restoration	4.8	0.40
Diabetes	4.9	0.29
Diagnosis	4.8	0.44
Drug allergies	4.9	0.29
Drug dose	4.9	0.29
Drug name	4.9	0.29
Existing restoration	4.9	0.35
Frequency of drug intake	4.9	0.35
Furcation involvement	4.8	0.43
Gingival bleeding	4.8	0.53
Hepatitis	4.9	0.35
Heart problem	4.8	0.40
List drug allergies	4.9	0.29
Medical problem	4.8	0.40
Open margin	4.8	0.43
Oral cancer screening	4.9	0.35
Oral screening findings	4.9	0.35
Periodontal disease classification	4.8	0.50
Periodontitis	4.8	0.43
Physician care	4.8	0.43
Plaque	4.8	0.40
Pocket depth	4.8	0.40
Pregnant	4.8	0.43
Pre-medication	4.9	0.35

Information Items	Mean	Standard Deviation
Prescribed medication	4.9	0.30
Presence of caries	4.9	0.29
Presence of pain	4.9	0.30
Probing depth	4.9	0.29
Progress notes	4.8	0.40
Proposed treatment	4.9	0.35
Tooth mobility	4.9	0.29
Treatment plan date	4.9	0.43
Type of Hepatitis	4.8	0.43

Table 5

List of the 45 information items rejected after the two rounds of the Delphi study (sorted alphabetically)

Information Items	Mean	Standard Deviation
Aggressiveness	2.5	1.24
Agitated	2.5	1.12
Attitude	2.5	1.15
Bored	2.4	1.12
Close friends	2.5	1.00
Cone length	2.6	1.20
Difficulty concentrating	2.5	1.09
Difficulty making decisions	2.5	1.23
Distracted	2.3	1.02
Energy	2.9	1.14
Excessive sleep	2.6	1.03
Excessive worry	2.4	1.19
Exposure to x-ray in seconds	2.6	1.17
Fear of dark	2.5	1.06
Feeling of inadequacy	2.5	0.98
Feeling of incompetent	2.3	1.02
Feeling of inferiority	2.6	0.93
Feeling restless	2.4	1.07
Feeling sad	2.4	1.02
Feeling sluggish	2.4	0.90
Feeling worthless	2.5	1.08
Floss brand name	2.8	0.81
Guilty	2.5	1.08
Have had abortion	2.5	0.86
Helplessness	2.5	0.93
Hopelessness	2.5	0.93
Horrible thoughts	2.4	1.12
Hostile	2.5	1.20
Irritability	2.5	1.17
Kilovoltage peak	2.6	1.12
Loneliness	2.4	1.08
Loss of appetite	2.6	0.94
Loss of memory	2.5	1.14
Loss of pleasure	2.6	1.03
Milliamperage	2.7	1.20
Miscarriage	2.6	1.11
Morally wrong	2.2	1.19
Naïve	2.4	0.92
Nightmares	2.5	1.08

Information Items	Mean	Standard Deviation
Obsessed with activities	2.5	1.03
Self-esteem	2.4	1.07
Sense of emptiness	2.3	0.97
Thinning of hair	2.6	0.96
Unpleasant future	2.4	0.97
Withdrawal from normal activities	2.6	1.03

Table 6

Top-level and second-level information categories, and number of information items they include

Top-level information category	2nd-level information category	# of information items
Alerts	N/A	6
Chief Complaint	N/A	6
Clinical Extra-oral Examination	Head and Neck Examination	10
	Tempero-Mandibular Junction Examination	24
Clinical Intra-oral Examination	Soft Tissue Condition	36
	Hard Tissue Condition	54
	Periodontal Condition	61
	Occlusion	23
	Previous Procedures	2
Comprehensive Health History	Allergies	32
	Family Medical History	5
	Medical History	31
	Past and Present Illness/Conditions/Diseases	159
	Vital Signs	7
	Women Only	7
Comprehensive Oral History	General Dental History	15
	Previous Dental Visit	5
	Previous Dental Care	21
	Homecare Regime	16
	Past and Present Dental Problems	36
	Parafunctional Habits	8
Consultation	N/A	10
Dental Radiographic Examination	Radiographic History	5
	Radiographic Findings	39
Diagnosis	Systemic Diagnosis	3
	Oral Diagnosis	30
	General Information	8
Management Considerations	Pre-medication	4
	Referral	10
	Current Medication	5
Medication History	Drug Usage Information: Individual Drugs	5
	Drug Usage Information: Drug Groups	29
Patient Education	N/A	6
Patient Instruction	N/A	4

Top-level information category	2nd-level information category	# of information items
Prescription	N/A	20
Problem List	N/A	8
Prognosis	N/A	3
Progress Notes	General Information	22
	Procedure Performed	8
	Anesthetic Usage	14
Risk Assessment	N/A	7
	Personal History	1
	Habit History	13
Social History		
	Addiction History	4
	Occupation History	1
Special Category Information Items		27
Treatment Plan	N/A	20
Grand Total		**870**