



## Formalizing the Austrian Procedure Catalogue: A 4-step methodological analysis approach



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### ABSTRACT

**Objectives:** Due to the lack of an internationally accepted and adopted standard for coding health interventions, Austria has established its own country-specific procedure classification system – the Austrian Procedure Catalogue (APC). Even though the APC is an elaborate coding standard for medical procedures, it has shortcomings that limit its usability. In order to enhance usability and usefulness, especially for research purposes and e-health applications, we developed an ontologized version of the APC. In this paper we present a novel four-step approach for the ontology engineering process, which enables accurate extraction of relevant concepts for medical ontologies from written text.

**Methods:** The proposed approach for formalizing the APC consists of the following four steps: (1) comparative pre-analysis, (2) definition analysis, (3) typological analysis, and (4) ontology implementation. The first step contained a comparison of the APC to other well-established or elaborate health intervention coding systems in order to identify strengths and weaknesses of the APC. In the second step, a list of definitions of medical terminology used in the APC was obtained. This list of definitions was used as input for Step 3, in which we identified the most important concepts to describe medical procedures using the qualitative typological analysis approach. The definition analysis as well as the typological analysis are well-known and effective methods used in social sciences, but not commonly employed in the computer science or ontology engineering domain. Finally, this list of concepts was used in Step 4 to formalize the APC.

**Results:** The pre-analysis highlighted the major shortcomings of the APC, such as the lack of formal definition, leading to implicitly available, but not directly accessible information (hidden data), or the poor procedural type classification. After performing the definition and subsequent typological analyses, we were able to identify the following main characteristics of health interventions: (1) Procedural type, (2) Anatomical site, (3) Medical device, (4) Pathology, (5) Access, (6) Body system, (7) Population, (8) Aim, (9) Discipline, (10) Technique, and (11) Body Function. These main characteristics were taken as input of classes for the formalization of the APC. We were also able to identify relevant relations between classes.

**Conclusions:** The proposed four-step approach for formalizing the APC provides a novel, systematically developed, strong framework to semantically enrich procedure classifications. Although this methodology was designed to address the particularities of the APC, the included methods are based on generic analysis tasks, and therefore can be re-used to provide a systematic representation of other procedure catalogs or classification systems and hence contribute towards a universal alignment of such representations, if desired.

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## 1. Introduction

The payment system of Austrian hospitals underwent a paradigm shift in 1997 [1]. Until then, hospitals had been reimbursed according to a so-called per-diem payment system [1]. This payment, which depended on the length of hospital stays of their patients, led to inefficient, long and expensive hospital stays [2]. To increase transparency and decrease the cost-explosion of health care, Austria implemented a performance-oriented hospital financing system based on modified diagnosis-related groups (DRG) [3]. Nowadays, in 2015, this system is still used in Austria. It allows for the billing of health services – including diagnoses as well as health interventions – to be rendered in hospitals. Such a payment model relies on accurate documentation and coding of diagnoses and health interventions. Diagnoses coding has been performed based on the International Classification of Diseases (ICD) [4] since 1989. While the ICD is an internationally accepted and commonly used standard, such a standard does not exist for procedure coding [5]. Therefore, Austria has developed its own country-specific classification system, which is called Austrian Procedure Catalogue (APC; German: Österreichischer Leistungskatalog) [6]. The Austrian Procedure Catalogue is the obligatory basis for procedure coding within the framework of the Austrian performance-oriented hospital financing system. In contrast to many mono-axial classification systems in the healthcare domain (e.g. ICD-10 [4]), the Austrian Procedure Catalogue (APC) offers a multi-axial architecture to classify health interventions [6]. APC codes are classified according to three independent axes: (1) Anatomical site, (2) Procedural Type, and (3) Access. The anatomical site axis describes the anatomical structure that is targeted by a specific medical procedure [6]. It is further subdivided into a general and a detailed anatomical site. While the general site provides a more general idea of the target region or body organ (e.g. “eye” [7]), the detailed site names the specific part of an organ targeted (e.g. “ocular muscles”). The procedural type explains the kind of medical procedures [6] (e.g. “therapy”, “in vivo diagnostic investigation/in situ diagnostic investigation” [7]). The third axis provides information about how the targeted anatomical region of a medical procedure is accessed. For example, the medical procedure “suture of ocular muscles” is classified according to the three axes as follows: (1a) general anatomical site: “eye”, (1b) detailed anatomical site: “ocular muscles”, (2) procedural type: “therapy”, and (3) access: “open access”.

Each medical procedure is represented by a so-called procedure code. For example, the code “BJ010” represents the previously mentioned medical procedure “suture of ocular muscles”. Additionally, a procedure has a procedure name and a textual description that provides more detailed information about the health intervention itself [7]. The APC contains approximately 1,500 procedure codes and is described in German. The APC was developed with the intention of it being used for billing and health policy making only, but it is also often employed for research purposes without paying any regard to the particularities of this field. Even though the Austrian Procedure Catalogue is an elaborate coding standard for procedure coding in general, it also has shortcomings that limit its usability, especially in the case of e-health applications or research purposes. A known shortcoming of the APC is that it offers a basic formal structure that allows a classification of terms according to three independent axes but does not support access to the full catalog in a machine-readable manner which is a first step towards semantic interoperability. Formal definition that allows the extraction of further information from the catalog is listed by Cimino [8] as an important desideratum for controlled vocabularies in the 21st century. Currently, the APC includes a list of procedure codes and descriptions in textual language that

makes interoperability or the use for e-health applications difficult. Since formal definition and semantically enriched representation support semantic interoperability, it is a major requirement for useful e-health applications to share machine-readable knowledge. Ontologies provide a formal representation of concepts of a domain as well as the relations among them [9] and are becoming more and more important in terms of domain knowledge representation and sharing. Biomedical ontologies address most of the desiderata for controlled vocabularies [9], which makes ontologies a useful and powerful solution for the representation of medical coding schemes [10].

This lack of formal definition motivated our analysis and led us to design an ontology in order to extend and improve the Austrian Procedure Catalogue. The aim of this ontology is to explain and model medical procedures performed in Austrian hospitals in more detail than the APC does in its current state, and to offer a framework for the Austrian hospital financing system, as well as to provide benefits for research and e-health applications. Based on popular methodologies for guiding the ontology engineering process [11] and considering the particular features of a procedure catalog, we designed a four-step methodology which stresses a combination of systematic analysis tasks for deriving the main concepts of the ontology with the support of domain experts without involving them in long time-consuming tasks. As the APC plays an important role within the framework of the performance-oriented hospital financing system, we had to take important features of the existing system (e.g. procedure codes, axes codes, initial classes) into account.

This combination of analysis tasks enabled us to identify the vocabularies and relations, which had to be included in the ontology. We were able to abstract common characteristics of health interventions from textual descriptions that are contained in the APC. A domain expert’s opinion was taken into account as the proposed analysis methods allowed us to receive feedback quickly and effectively and thus facilitated their involvement at the validation stage without excessive time demand. Hence, the aim of this paper is to present the four-step methodological approach used for the ontology engineering process that facilitates the identification of main concepts inside a procedure catalog system, which was successfully used to design an ontological model of the APC. These analysis tasks allow an accurate and systematic extraction of the required concepts and vocabularies and could also be applied to develop other ontologies in the medical field.

The remainder of this paper is organized as follows: Section 2 presents the background and state of the art, Section 3 includes a detailed description of the methods involved in the proposed methodological approach. In Section 4, the outcomes of each respective step are described. Section 5 discusses the obtained results and finally, conclusions are presented in Section 6.

## 2. State of the art

The following section presents related work and the contributions of our work to the state of the art are clarified.

### 2.1. Ontologies and vocabularies for medical procedures

As of today, structured data about medical procedures is barely comparable on an international level [5]. Many different classification systems exist for health interventions like the German Operationen- und Prozedurenschlüssel (OPS) [12], the American Current Procedural Terminology (CPT) [13] or the French Classification Commune des Actes Médicaux (CCAM) [14]. The APC is a fairly small and simple catalog, mainly used for billing and health

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