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# Optimizing Clinical Coding Systems: Design Principles, Applications, and Challenges

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**Abstract**

Clinical coding systems play a crucial role in transforming medical concepts into a structured format suitable for computational analysis. However, the development of an ideal coding system remains a challenge due to the diverse requirements and benefits sought by the medical community. This paper explores the design principles and attributes of an effective clinical coding system, drawing on the foundational framework proposed by James Cimino. Key features include non-ambiguity, non-vagueness, non-redundancy, inviolability, evolvability, consistency, and polyhierarchy. The concept of polyhierarchy is examined in depth, highlighting its ability to accurately represent the complex relationships between medical concepts. The paper also discusses the benefits of implementing a well-designed clinical coding system at local, national, and international levels, such as enhanced auditing capabilities, improved communication among healthcare teams, and the ability to identify global health inequalities. Furthermore, the paper delves into the intricacies of surgical reimbursement, explaining the concept of global surgery packages and the appropriate use of modifiers and add-on codes. Understanding these concepts is crucial for ensuring accurate billing and compliance with reimbursement policies. The paper emphasizes the importance of precise documentation and coding practices in reflecting the complexity and value of surgical services provided.

**Keywords:** Clinical Coding, Medical Classification Systems, Healthcare Data Management, Electronic Health Records EHR, Clinical Terminologies.

## Introduction

For healthcare professionals, it can be challenging to maintain enthusiasm for accurate clinical coding, particularly when commonly used medical terminology suffices to communicate essential health information within a clinical team. For instance, the shorthand "PSHx: right hemi" is generally understood among general surgeons to signify a previous surgical history of "right hemicolectomy." However, this information, when copied from a discharge letter into a general practitioner's notes, becomes ambiguous and potentially misleading over time. Decades later, without context, it may raise questions such as whether the patient underwent a bowel surgery or a hip replacement. If clinical coding had been utilized instead, such as recording "H06.1 Extended right hemicolectomy and end-to-end anastomosis" using the OPCS-4 system Operating Procedure Codes Supplement, the ambiguity would be avoided Dotson, 2013.

A clinical coding system is designed to transform medical concepts—an interplay of language and clinicians' interpretation of it—into a formal language. A formal language, by definition, comprises a predetermined set of symbols or words and specific rules governing their usage. In the OPCS-4 system, for example, a code consists of a letter, two digits, and optionally a third digit preceded by a period. The primary advantage of such a system is its ability to represent medical concepts in a structured format suitable for computational analysis Metcalfe et al., 2019.

The earliest clinical coding system was the Read Codes, named after James Read, which provided a framework for coding in general practice. However, a significant limitation of this system was its narrow scope, as it was not designed to address medical fields beyond general practice. Furthermore, it emerged at a time when computing resources were rudimentary, limiting its utility. Similarly, the OPCS-4 system, while valuable for procedural coding, is not well-suited for encoding psychiatric diagnoses. To address this, psychiatrists rely on their own coding system, the DSM-5 Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition. A summary of these and other coding systems is presented in Table 1. The central issue with most coding systems is their tendency to be overly specific to one specialty, rendering them either too vague or inapplicable for others. Even within specialized systems, challenges persist. For instance, in the OPCS-4 coding system, the code H09.4 corresponds to "Left hemicolectomy and ileostomy HFQ," where "HFQ" denotes "however further qualified." While this level of specificity may suffice for billing purposes, it fails to distinguish between an end ileostomy and a loop ileostomy—a distinction that holds considerable surgical significance. Similarly, variations in procedures or diagnoses may not fit neatly into existing categories, and evolving medical practices may exacerbate this issue. Consequently, a poorly designed coding system risks sacrificing complexity and detail, undermining its intended purpose.

Table 1. A non-exhaustive selection of clinical coding systems

| Short name | Long name |
|---|---|
| Read codes | Eponymously named after James Read |
| OPCS-4 | Office of Population Censuses and Surveys |
| CPT | Current Procedural Terminology |
| DSM-V | Diagnostic and Statistical Manual |
| ICD-10 | International Classification of Diseases |
| ICD-10-PCS | ICD-10 Procedure Coding System |
| HIPE | Hospital Inpatient Enquiry |
| ICNARC | Intensive Care National Audit and Research Centre |
| SICSAG | Scottish Intensive Care Society Audit Group |
| SNOMED CT | Systematized Nomenclature of Medicine Clinical Terms |

**Coding System Design**

The existence of numerous clinical coding systems underscores the reality that no single system has successfully addressed the diverse requirements and benefits sought by the medical community. The development of an ideal clinical coding system remains elusive, as each current system tends to cater to specific needs while neglecting others. This raises the question: what attributes would such an ideal system need to possess? Addressing this query comprehensively would necessitate a detailed exploration of information theory. However, a foundational framework for these design principles has been proposed by James Cimino, whose work serves as a practical starting point for conceptualizing an effective system Topaz et al., 2013.

Cimino's principles, summarized in Table 2, articulate several key features that an ideal clinical coding system should embody. Foremost among these is non-ambiguity, which ensures that each code is associated with a single, distinct meaning. This principle eliminates confusion that could arise when a single code is interpreted in multiple ways, thereby fostering clarity in communication. Equally important is non-vagueness, which mandates that every code must convey at least one clear and specific meaning, ensuring that codes are meaningful and actionable in clinical practice.

Another essential feature is non-redundancy. This principle stipulates that each concept should have one and only one corresponding code. Redundancy in coding systems can lead to inefficiencies and errors, as clinicians and analysts may inadvertently select different codes for the same concept, leading to inconsistencies in medical records and data analysis. Moreover, codes must be inviolate, meaning that once a code is established, it should not be removed or reassigned. This ensures the stability and longevity of the coding system, which is critical for maintaining historical data integrity and enabling longitudinal studies Marchetti et al., 2022.

To adapt to the evolving nature of medical knowledge and practices, the coding system must also be evolvable. This feature allows the system to accommodate new concepts, procedures, and diagnoses as they emerge, ensuring that it remains relevant and reflective of contemporary medicine. Consistency is another critical attribute, ensuring that the system is applied uniformly across different users, institutions, and contexts. Without consistency, the utility of a coding system is significantly diminished, as discrepancies in application undermine its reliability and validity.

Finally, an ideal coding system should embrace polyhierarchy. This principle allows for multiple "is-a" relationships between codes, reflecting the complex and interrelated nature of medical concepts. For instance, a single procedure might belong to multiple categories based on its purpose, technique, or anatomical location. A polyhierarchical structure enables a more nuanced representation of such relationships, enhancing the system's utility for various purposes, including clinical decision-making, research, and billing.

Table 2. Design requirements for a clinical coding system

| **Feature** | **Meaning** |
|---|---|
| Non-ambiguous | Codes have no more than one meaning<br>“Diabetes’’ could be “Diabetes mellitus” or “Diabetes insipidus” |
| Non-vague | Codes have at least one meaning<br>Diabetes means “to pass through”, but this by itself is not a useful code |
| Non-redundant | Meanings correspond to only one code<br>Only one way to code for “Diabetes mellitus”. Note that with a hierarchy it would be acceptable for there to be a subset of this code for “type 1” and “type 2” |
| Inviolate | Once a concept is created, it remains<br>Outdated terms can be marked as no longer in use, but they will always remain. For example, hard as it may be to imagine, concepts like “Systemic Inflammatory Response Syndrome” and “Sepsis” may disappear from common use as our understanding of this improves |
| Evolvable | Should be able to change as our medical model changes<br>Minor name changes, discovered redundancy, refinements are fine; major name changes, code reuse and changing of codes are not: previously coded “Sepsis” should not be renamed “SIRS plus documented infection” and other ways of distinguishing them should be used, e.g. timing of new sepsis guideline publication, or entirely new terms |
| Granular | Multiple levels of meaning<br>“Diabetes mellitus” might be appropriate for some people, others may need “Type 2 diabetes mellitus” or further “Type 2 diabetes mellitus on insulin” |
| Consistent | Coding should be applied consistently by users<br>This is more an issue of implementation: too many options and users may just apply the most convenient rather than the most applicable code |
| Polyhierarchial | Codes should be allowed multiple is a relationships with other codes<br>This would allow “diabetic retinopathy” to be classed as a subset of not only a complication of diabetes, but also as a subset of eye disease separately without any issues of redundancy |

One feature deserving of deeper examination is the concept of polyhierarchy within clinical coding systems. Most current systems, such as ICD-10, are built around a tree-like classification model. While this structure offers simplicity and clarity, it has notable limitations. Specifically, if a concept logically belongs to more than one branch, the system must make a compromise. This typically results in the concept being assigned to just one branch, or alternatively, the creation of an entirely new branch to encompass the intersecting categories. An example of this limitation can be observed with “K76.7: Hepatorenal syndrome,” which describes impaired renal function associated with end-stage liver disease. In ICD-10, this condition is classified within the K70-77 range, designated for diseases of the liver. However, considering that the primary clinical concern with this syndrome pertains to its impact on the kidneys, it could arguably be placed under the N18 category for "Chronic kidney disease" instead.

This classification choice presents additional challenges. For instance, there are two distinct forms of hepatorenal syndrome: type 1 and type 2. These differ significantly in terms of onset, progression, and mortality. It could be argued that type 1 hepatorenal syndrome, given its acute nature, might be better classified under N17, which covers "Acute kidney failure." In contrast, type 2 hepatorenal syndrome, with its slower progression, might align more naturally with chronic kidney disease categories. A polyhierarchical coding system would effectively resolve these dilemmas by allowing the condition to be classified under multiple relevant headings. For example, it could simultaneously fall under liver diseases and kidney diseases based on organ systems, under a broader heading of hepatorenal syndromes as a distinct disease category, and finally, differentiate type 1 and type 2 based on acute or chronic kidney conditions. This flexibility provides a more accurate and comprehensive representation of medical concepts, as illustrated in Figure 1. The formal linguistic and structural underpinnings of polyhierarchical systems have been thoroughly explored by Zweigenbaum et al..

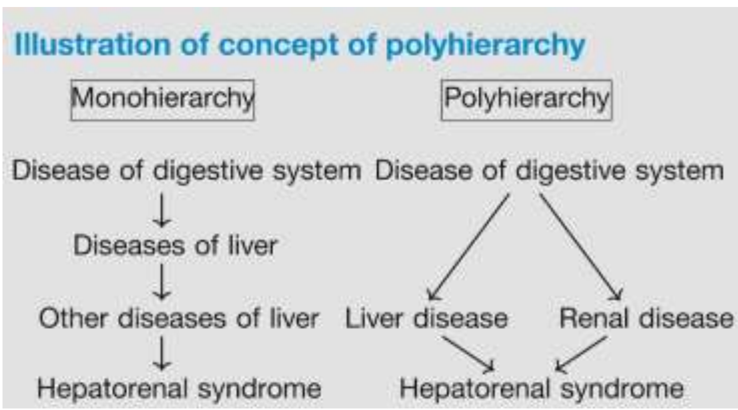


Figure 1.

**Uses for Clinical Coding**

The implementation of a well-designed clinical coding system brings significant advantages at local, national, and international levels. On the local scale, hospitals and medical practices benefit from enhanced auditing capabilities, robust decision support systems, improved communication among healthcare teams, and streamlined medical billing processes. For instance, clinical coding ensures consistency in documenting procedures and diagnoses, making it easier to evaluate the quality of care and identify areas for improvement. Additionally, decision support systems that rely on coded data can provide clinicians with real-time insights and alerts, such as identifying contraindications or recommending evidence-based interventions, thereby improving patient outcomes.

At the national level, clinical coding supports large-scale epidemiological studies and resource allocation. By aggregating coded data from numerous healthcare providers, public health officials can identify patterns of disease prevalence, assess the effectiveness of interventions, and monitor emerging health threats. This data also plays a crucial role in guiding policy decisions and determining where to allocate resources, such as funding for new facilities or programs. For example, the identification of a regional increase in certain types of cancer could inform strategic investments in specialized oncology services or targeted public health campaigns Peters, 2020.

On the international stage, clinical coding facilitates global health reporting, enables the monitoring of health inequalities, and improves cross-border communication among healthcare providers. Standardized coding systems allow countries to contribute to and analyze data from international databases, fostering collaboration in addressing global health challenges. Additionally, consistent coding enables comparisons of health outcomes across different regions and populations, shedding light on disparities that may warrant further investigation and intervention. For instance, coding data can reveal variations in access to treatments or disparities in disease outcomes, providing evidence for targeted global health initiatives. A detailed breakdown of these benefits can be found in Table 3.

By ensuring accuracy, consistency, and flexibility, a robust clinical coding system can serve as an indispensable tool for advancing healthcare delivery and improving health outcomes on multiple levels.

Table 3. Uses of clinical coding systems

| Level | Use | Description |
|---|---|---|
| Local | Audit | Able to track specific diseases, interventions and whether guidelines are followed |
| | Research | Investigate response to specific interventions |
| | Decision support systems | Suggest investigations to clinicians, provide scoring systems, link to relevant information and guidelines |
| | Accurate communication | Unambiguously communicate diagnoses and procedures without the confusion of abbreviations |
| | Medical billing | Renumeration from the government e.g. National Tariff Payment System within the UK or billing of patients and insurance companies privately |
| National | Epidemiology | Detection of emergence of new disease or trends in existing |
| | Resource allocation | Strategically develop services to meet regional health needs based on epidemiology |
| International | Reporting | World Health Organization statistics |
| | Health inequality | Examination of differences in access to healthcare across socio-economic regions |
| | Communication | Guidelines and unambiguous disease classification regardless of language |

**Understanding Global Periods in Surgical Reimbursement**

Reimbursement for most surgical procedures is governed by the concept of a “global surgery package.” Under this framework, the payment for a surgical procedure encompasses all services typically provided by the surgeon before, during, and after the procedure within a defined period. Some procedures, such as endoscopies and certain minor surgical interventions, do not have a global period, meaning their reimbursement is limited to the procedure itself. Other minor procedures are assigned a 10-day global period, which includes the procedure and any related services provided within the subsequent 10 days. For these procedures, the initial evaluation is bundled into the payment when performed on the same day. In contrast, major surgical procedures are associated with a 90-day global period. This includes services rendered on the day before the procedure, the day of the procedure, and all related postoperative services within the following 90 days Erickson, 2017.

Despite these general guidelines, there are notable exceptions to the standard global surgery packages. For instance, if a diagnostic procedure with a 10-day global period reveals the necessity for a major surgical procedure during that timeframe, the subsequent major procedure can be billed separately. Another exception applies to postoperative complications that necessitate a return to the operating room. In such cases, the additional procedures are billable independently, even if they occur within the 90-day global period. These scenarios require the use of specific modifiers, such as the −78 modifier, which indicates a return to the operating room for a procedure related to the original surgery.

Certain exceptions to global period rules necessitate the use of modifiers appended to the Current Procedural Terminology CPT® code for the service. For instance, in the context of a 10-day global period, an evaluation and management E/M service performed on the day of the procedure may be billed separately if it addresses a distinct issue unrelated to the procedure itself. Consider a patient presenting with rectal bleeding. The initial history and physical examination constitute an E/M service aimed at developing a differential diagnosis and formulating an evaluation plan. If this process leads to a recommendation for an anoscopy to assess the anorectal mucosa and investigate the source of bleeding, the E/M service can be billed using the appropriate CPT® code for the level of service, augmented with the −25 modifier. This modifier signifies that a separately identifiable service was provided by the same clinician on the same day. The anoscopy itself would then be billed as a distinct procedure. Conversely, if the anoscopy is performed on a different day, the E/M service from the initial visit would be billed without a modifier, and the anoscopy would be billed independently for the subsequent encounter.

Similarly, exceptions exist for procedures associated with a 90-day global period. Typically, the global bundle encompasses services provided on the day of surgery and the preceding day. However, if the service rendered involves an initial evaluation to determine the necessity for surgery, it can be billed separately using the appropriate CPT® code with the −57 modifier. This modifier signifies that the service directly led to the “Decision for Surgery.” For example, if a surgeon evaluates a patient with diverticulitis and concludes that urgent surgical intervention is required, the consultation is billed with the −57 modifier, and the surgical procedure is billed independently. Alternatively, if a patient is evaluated in the office, scheduled for elective surgery six weeks later, and subsequently seen on the day of surgery for an updated history and physical examination, the latter service is not billable. In this scenario, the decision for surgery was made during the initial evaluation, and the preoperative visit on the day of surgery is included within the global package.

Understanding and applying the appropriate use of global periods and modifiers is crucial for ensuring accurate billing and compliance with reimbursement policies. These rules are designed to balance fairness in compensation while avoiding duplication of payments for services that are inherently bundled into surgical care.

**Coding for Multiple Procedures in Surgical Billing**

Although the CPT® system includes nearly 10,000 codes for various medical services, situations often arise where a single code cannot adequately represent all the procedures performed during a surgical operation. For example, during a laparoscopic colectomy for sigmoid colon cancer, a surgeon might identify an unexpected liver lesion suspicious for metastasis and proceed to perform a wedge excisional biopsy. The appropriate CPT® code for the laparoscopic partial colectomy would be 44204 Laparoscopy, surgical; colectomy, partial, with anastomosis. The secondary procedure, the liver biopsy, would be reported using code 47100 Biopsy of liver, wedge. To signify that the biopsy is a secondary procedure, the modifier −51 is appended to the liver biopsy code, resulting in 47100-51.

In most cases, Medicare and other insurance providers reduce the reimbursement for secondary procedures by 50%. This reduction reflects the understanding that a portion of the work required for the secondary procedure overlaps with the work done for the primary procedure. For instance, in the example provided, certain aspects of the patient’s care, such as the evaluation and management E/M services, placement of laparoscopic trocars, and postoperative care, are already covered by the primary colectomy code.

**Understanding Bundling in Surgical Coding**

Before submitting a code for a secondary procedure, it is essential for the surgeon to clearly understand the scope of the primary procedure code. Using the example of laparoscopic colectomy for cancer, a laparoscopic survey of the abdomen to assess for metastatic disease is a standard component of the procedure. While a code exists for diagnostic laparoscopy 49320: Laparoscopy, abdomen, peritoneum, and omentum, diagnostic, with or without collection of specimens by brushing or washing, it cannot be billed as a secondary procedure in this context for two reasons.

First, the descriptor for code 49320 explicitly states that it is a “separate procedure,” meaning it cannot be billed in conjunction with another procedure. Second, the exploration of the abdominal cavity is already incorporated into the laparoscopic colectomy process. Attempting to bill such components as separate secondary procedures constitutes “unbundling,” which refers to the improper practice of listing a part of an included procedure as an additional one. Claims involving unbundling are typically rejected by payers and may be subject to repayment if uncovered during an audit.

**Add-On Codes and Their Role in Surgical Billing**

Add-on codes serve a purpose similar to modifiers in that they provide supplementary information about the primary procedure performed. These codes are five-digit CPT® codes designed to describe procedures frequently performed in conjunction with specific listed procedures. Unlike standard secondary codes, add-on codes cannot be billed independently; they must always accompany a primary procedure code. Furthermore, add-on codes are exempt from the −51 modifier typically used for secondary procedures.

For colorectal surgeons, particularly relevant add-on codes include 44139 and 44213. These codes describe the mobilization of the splenic flexure during open and laparoscopic partial colectomies, respectively. Importantly, these codes can only be used in conjunction with specific colectomy codes, namely 44140-44147 for open procedures and 44204-44208 for laparoscopic procedures. They cannot be utilized independently or with codes outside these specified ranges. When appropriately applied, add-on codes do not require the −51 modifier and are not subject to the Multiple Procedure Payment Reduction MPPR, ensuring full reimbursement for the additional work performed during the primary surgery.

This nuanced approach to coding for multiple procedures, including the use of modifiers, bundled components, and add-on codes, underscores the importance of precise documentation and coding practices. These practices not only ensure compliance with reimbursement policies but also reflect the complexity and value of the services provided.

**Conclusion**

Clinical coding systems serve as a cornerstone in accurate documentation and computational analysis of medical concepts. Despite the diverse array of systems available, each has limitations that prevent the realization of a universally ideal framework. The principles proposed by Cimino—such as non-ambiguity, evolvability, and polyhierarchy—highlight the foundational attributes required for a robust system capable of addressing the evolving needs of modern medicine.

The effective implementation of coding systems offers substantial benefits across local, national, and international levels. Locally, it supports enhanced auditing, facilitates clear communication among healthcare teams, and optimizes billing practices. Nationally, it contributes to epidemiological analysis and informed resource allocation, while internationally, it enables global health reporting and the monitoring of healthcare disparities.

The application of coding systems in surgical reimbursement further emphasizes their importance. Concepts like global periods, modifiers, bundling, and add-on codes underscore the necessity for precision in coding practices to ensure fair and compliant reimbursement. The ability to accurately document complex procedures, manage exceptions, and avoid pitfalls like unbundling reflects the need for a nuanced understanding of these systems.

In summary, clinical coding systems are indispensable tools in bridging the gap between medical practice and computational representation. Their continued development and refinement are critical for advancing healthcare delivery, fostering innovation, and addressing the complex challenges of a dynamic medical landscape.

**References**

Dotson, P. 2013. CPT® Codes: What Are They, Why Are They Necessary, and How Are They Developed? *Advances in Wound Care*, *2*10, 583–587. https://doi.org/10.1089/wound.2013.0483

Erickson, M. L. 2017. Payment Basics. In *Documentation Basics for the Physical Therapist Assistant* 3rd ed.. Routledge.

Marchetti, C., Cantoni, A. M., Ferrari, L., Pisani, G. M., & Corradi, A. 2022. Use of the international classification of diseases ICD-11 method applied to veterinary forensic pathology for coding the cause and manner of death in wildlife. *Frontiers in Veterinary Science*, *9*. https://doi.org/10.3389/fvets.2022.898721

Metcalfe, D., Zogg, C. K., Haut, E. R., Pawlik, T. M., Haider, A. H., & Perry, D. C. 2019. Data resource profile: State Inpatient Databases. *International Journal of Epidemiology*, *48*6, 1742–1742h. https://doi.org/10.1093/ije/dyz117

Peters, W. R. 2020. Billing/coding tips from the pros: How important is this stuff, and what does the future hold? *Seminars in Colon and Rectal Surgery*, *31*1, 100712. https://doi.org/10.1016/j.scrs.2019.100712

Topaz, M., Shafran-Topaz, L., & Bowles, K. H. 2013. ICD-9 to ICD-10: Evolution, revolution, and current debates in the United States. *Perspectives in Health Information Management*, *10*Spring, 1d.