EVALUATION OF INTERNATIONAL CLASSIFICATION OF DISEASE: FROM ICD - 1 to ICD - 11

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Abstract

The International Classification of Diseases (ICD), developed by the World Health Organization (WHO), is a globally standardized system used for coding and classifying diseases, health conditions, injuries, and causes of death. This review paper evaluates the evolution of ICD from ICD-1 to ICD-11, highlighting major historical developments, structural changes, applications, challenges, and future perspectives. Over time, the ICD has evolved from simple mortality-based listings into a highly detailed, clinically relevant, and digitally integrated classification system. ICD-10 marked a major advancement with the introduction of an alphanumeric coding structure and widespread global adoption, while ICD-11 represents a transformative shift toward a fully digital, ontology-based system with enhanced flexibility and interoperability for integration with electronic health records and modern health information systems. The ICD system plays a crucial role in epidemiology, health policy formulation, clinical documentation, insurance processing, and global health reporting. However, challenges such as implementation complexity, training requirements, resource limitations, and data inconsistency continue to affect its optimal use, particularly in developing regions. With the increasing adoption of artificial intelligence and digital health technologies, ICD is expected to become an even more dynamic and intelligent tool for global health data management and decision-making.

Keywords: *International Classification of Diseases (ICD); ICD evolution; ICD-10; ICD-11; disease classification system; medical coding; health informatics.*

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1. INTRODUCTION

A widely accepted standardized system for the classification, coding, and reporting of illnesses, injuries, and reasons of death is the International Classification of Diseases (ICD). The World Health Organization (WHO) maintains and updates it on a regular basis. It is an essential instrument for clinical practice, epidemiological research, health management, and the creation of global health policies. According to the World Health Organization [WHO], 2019; Mathers et al., 2006, the ICD promotes consistency in the reporting of health data, making it possible to compare morbidity and death rates meaningfully across various populations, geographical areas, and time periods.

The historical requirement for the systematic documentation of disease patterns served as the foundation for the formation of ICD. International comparisons of health data were extremely uneven and untrustworthy prior to its creation since different countries employed different terminology and classification schemes. Planning for public health, illness surveillance, and medical research were all severely hampered by this lack of consistency. Early initiatives to solve these problems, such the Bertillon categorization of Causes of Death, established the groundwork for a globally recognized disease categorization system that eventually developed into the current ICD framework (Moriyama et al., 2011; Rosenberg, 2012).

The ICD has undergone numerous updates throughout time to reflect changes in illness patterns, advances in medical understanding, and the increasing complexity of healthcare systems. Structure, code accuracy, and usability all improved with each release. From a straightforward mortality-based listing system to a highly complex, digital, and clinically integrated classification framework, the shift from ICD-1 to ICD-11 shows a clear trend. With the addition of digital technology, increased coding flexibility, and better connection with electronic health data, the most current edition, ICD-11, marks a substantial transition (WHO, 2019; Harrison et al., 2021).

ICD is essential to evidence-based medicine, the creation of health statistics, the distribution of resources, insurance systems, and worldwide disease surveillance in modern healthcare systems. Additionally, it is crucial for tracking public health trends, assessing medical results, and directing decisions about global health policy. ICD is becoming an increasingly important part of contemporary health informatics due to the growing integration of digital health technologies and artificial intelligence.

The objective of this review article is to objectively assess the development of the ICD system from ICD-1 to ICD-11, emphasizing significant turning points, structural advancements, applications, difficulties, and prospects for global health categorization systems.

2. Historical Development of ICD

The International Classification of Diseases (ICD) is a globally standardized diagnostic classification system used for coding diseases, disorders, injuries, and causes of death. Its development marks a significant turning point in epidemiology and public health informatics by making it possible to systematically gather, analyze, interpret, and compare health data across populations and eras. Over a century of worldwide cooperation aimed at enhancing the accuracy and comparability of mortality and morbidity statistics is reflected in the development of ICD (World Health Organization [WHO], 2019; Moriyama et al., 2011).

ICD has its roots in public health reforms of the 19th century, when the necessity for systematic mortality records grew as urbanization and industrialization increased. It was challenging to perform significant international comparisons at the time due to variations in disease terminology and reporting procedures between nations. Early attempts to create uniform categorization schemes for causes of death were spurred by this difficulty.

2.1 Early Beginnings of Disease Classification

The Bertillon Classification of Causes of Death, developed in 1893 by French statistician Jacques Bertillon, is considered the earliest widely recognized precursor to the International Classification of Diseases (ICD). Established under the authority of the International Statistical Institute (ISI), it represented one of the first systematic efforts to standardize mortality statistics across countries (Bertillon, 1893; Eyler, 1979). The system organized causes of death into a hierarchical structure based on anatomical and pathological principles, including categories such as infectious diseases, respiratory disorders, digestive system diseases, and external causes like injuries and accidents. Its primary aim was to ensure uniform reporting of mortality data, enabling meaningful international comparison of health statistics (Horton, 2013; Moriyama et al., 2011).

Due to its simplicity and practical design, the Bertillon system was widely adopted in Europe and North America and became the foundation for international mortality statistics following its endorsement at early international statistical congresses. Revisions in 1900, 1909, and 1920 reflected early attempts to improve its structure and adapt it to evolving health patterns (Anderson, 2011; Rosenberg, 2012). However, its limitations included a narrow focus on mortality data, absence of morbidity classification, and lack of a permanent governing authority, leading to inconsistencies in implementation across countries (Bowker & Star, 1999; Sousa et al., 2007).

Growing international cooperation in public health during the early 20th century led to the development of the International List of Causes of Death (1900), which was directly derived

from the Bertillon system and is recognized as the foundation of ICD-1. Subsequent revisions through international conferences (1909, 1920, and 1929) improved consistency and standardization in health statistics. With the establishment of the World Health Organization (WHO) in 1948, responsibility for ICD development was centralized, marking a transition from fragmented national systems to a globally governed classification framework that later incorporated both mortality and morbidity data (WHO, 2019; Mahapatra et al., 2007).

2.2 ICD-1 (1900)

The period covering **ICD-2 (1910), ICD-3 (1920), and ICD-4 (1930s)** represents an important phase of progressive refinement in the International Classification of Diseases, during which the system gradually improved in structure, consistency, and international acceptance. These revisions were primarily driven by the need to enhance the accuracy and comparability of mortality statistics across countries. Each successive edition expanded and reorganized disease categories, improving clarity in classification and incorporating advances in medical knowledge. ICD-3 and ICD-4, in particular, reflected stronger international collaboration through periodic revisions agreed upon at global statistical conferences, which helped strengthen standardization efforts in health reporting (Anderson, 2011; Moriyama et al., 2011).

During this period, the classification system also became more detailed, with better differentiation of infectious diseases, chronic conditions, and external causes of death. However, despite these improvements, the system still remained largely focused on mortality data and lacked integration of morbidity or clinical applications. Variability in national implementation and the absence of a permanent governing authority continued to pose challenges for uniform application. Nevertheless, ICD-2 to ICD-4 played a crucial role in strengthening global statistical cooperation and laid the groundwork for the more structured and internationally governed ICD system that emerged under the World Health Organization in later years (Bowker & Star, 1999; WHO, 2004).

2.3 ICD-2 to ICD-4 (1910-1930s)

ICD-2 (1910), ICD-3 (1920), and ICD-4 (1930s) represent a phase of gradual refinement in the International Classification of Diseases, where improvements were made incrementally to enhance clarity, consistency, and international usability. These revisions focused on improving mortality reporting by reducing ambiguity in disease terminology, standardizing classification practices, and strengthening comparability of health statistics across countries (WHO, 2004; Haupt & Huber, 2015). ICD-3 and ICD-4 further expanded disease categorization and incorporated expert feedback from international statistical conferences,

reflecting ongoing efforts to align the system with evolving medical knowledge (López & Salomon, 2014). During this period, disease classification also became more detailed, with better representation of infectious, chronic, and organ-system diseases, although the system still remained largely limited to mortality data and did not include morbidity or clinical applications. Despite limitations and inconsistent national implementation, this era played a crucial role in strengthening early international cooperation and laid the foundation for the later establishment of a centralized WHO-led ICD system (Omran, 2005; Vallin & Meslé, 2012).

2.4 ICD-5 (1938)

An key step toward improving the categorization system's depth, specificity, and usability was the 1938 introduction of the Fifth Revision of the International categorization of Diseases (ICD-5). This update was created at a time when medical knowledge was developing quickly and there was an increasing need for more precise and consistent health data. ICD-5 indicated a greater focus on enhancing the comparability of mortality data across nations and was impacted by previous international statistical initiatives (World Health Organization [WHO], 2004; Moriyama et al., 2011).

ICD-5's greater degree of information and broader classification breadth were among its main characteristics. ICD-5 included better hierarchical architecture and more precise disease classifications than previous iterations. This made it easier to distinguish between illnesses with comparable clinical manifestations, especially in fields like respiratory disorders, cardiovascular ailments, and infectious diseases. Additionally, the change improved coding accuracy, increasing its utility for administrative and statistical objectives in public health systems (Anderson, 2011; Rosenberg, 2012).

International cooperation in health statistics grew stronger during this time. The necessity for a centralized body to oversee illness classification was becoming more and more important in discussions within the global public health and statistics communities, even though the World Health Organization had not yet been founded. These conversations had an indirect impact on WHO's subsequent establishment and its eventual oversight of ICD management. ICD-5 might therefore be viewed as a phase of transition that connected early statistical endeavors with contemporary global health governance frameworks (Bowker & Star, 1999; López & Salomon, 2014).

2.5 ICD-6 (1948) - First WHO Edition

Since it was the first version created under the World Health Organization's (WHO) jurisdiction, the 1948 introduction of the Sixth Revision of the ICD (ICD-6) marks a

significant turning point in the history of disease classification. Global health governance underwent a sea change with the founding of WHO in 1948, which made it possible for centralized coordination, frequent review cycles, and uniform international use of the ICD system (WHO, 2004; Mahapatra et al., 2007).

The formal transition from a mortality-based system to one that includes morbidity data was one of the biggest modifications made to ICD-6. By enabling the recording of non-fatal diseases, hospital diagnoses, and more general health problems, this addition significantly improved the classification system's clinical and epidemiological utility. This change was a reflection of the increasing realization that death numbers alone were insufficient to fully comprehend the burden of disease (Salomon et al., 2012; WHO, 2019).

A significant structural change to the classification system was also implemented by ICD-6. It established a more organized hierarchical structure, increased the number of categories, and enhanced the logic for grouping diseases. Instead of being restricted to vital statistics offices, these modifications made the ICD more appropriate for use in hospitals, research facilities, and national health systems. Additionally, the update enhanced uniformity in coding procedures and established the framework for upcoming clinical modifications to the ICD system (Haupt & Huber, 2015).

WHO's contribution to ICD-6 was very important since it guaranteed worldwide standards and ongoing revision processes. WHO created a permanent institutional framework for handling upgrades and guaranteeing worldwide adoption, in contrast to previous iterations that depended on recurring international conferences. This change made the ICD a cohesive worldwide health information standard instead than a disjointed statistical tool (Omran, 2005; Vallin & Meslé, 2012).

3. Evolution of ICD Editions (ICD-7 to ICD-9)

A pivotal stage in the development of the International Classification of Diseases occurred between ICD-7 and ICD-9 (1955-1975), when the system evolved from a predominantly mortality-focused statistics tool into a more sophisticated, clinically relevant classification framework. Due to the rapid advancement of modern medicine and the increasing demand for standardized health information systems, this era was marked by ongoing methodological improvements, the expansion of disease categories, and rising global adoption (World Health Organization [WHO], 2004; Moriyama et al., 2011).

The ICD system started to become more tightly aligned with clinical practice, epidemiological research, and hospital record-keeping during this period, indicating a change from demographic reporting to more comprehensive healthcare applications.

3.1 ICD-7 (1955)

An important step in the improvement of the classification system was the introduction of the Seventh Revision of ICD (ICD-7) in 1955. Building on the fundamental modifications made in ICD-6, the main goal of this revision was to enhance the structure, consistency, and clarity of disease coding. In order to improve statistical accuracy and cross-national comparability, ICD-7 added more systematic disease classification while maintaining the general framework previously established (WHO, 2004).

The improvement of definitions and coding guidelines in ICD-7 was a crucial component that lessened uncertainty in the classification of diseases. This was especially crucial for enhancing the accuracy of mortality data gathered from various healthcare systems. Furthermore, although its application was still mostly limited to mortality reporting rather than clinical recording, ICD-7 represented early attempts to modify the classification system to developing epidemiological needs (Anderson, 2011; Rosenberg, 2012).

Increased international collaboration under the World Health Organization, which guaranteed more uniformity in implementation among member states, also helped ICD-7. Nonetheless, differences in national adoption persisted, underscoring the necessity of additional uniformity in later versions.

3.2 ICD-8 (1965)

An important step forward in the development of the ICD system was the introduction of the Eighth Revision (ICD-8) in 1965. This version, which reflected developments in epidemiology and medical science in the middle of the 20th century, greatly increased categorization accuracy and structural structure.

ICD-8 enhanced hierarchical architecture and added more specific disease categories, making it easier to distinguish between identical disorders. The approach became more valuable for worldwide health comparisons, health care planning, and epidemiological research due to its improved precision. Additionally, it boosted global adoption by strengthening the uniformity of coding practices across nations (López & Salomon, 2014; Moriyama et al., 2011).

The growing adoption and use of the classification system throughout the world throughout the ICD-8 era was another significant development. As its significance in public health surveillance became increasingly apparent, more nations started implementing ICD standards for national health reporting systems. ICD's position in global health governance was significantly strengthened during this time due to its greater integration into administrative and statistical systems (Bowker & Star, 1999).

3.3 ICD-9 (1975)

An important turning point in the development of the ICD system was the introduction of the Ninth Revision (ICD-9) in 1975, which greatly extended its use beyond mortality data. ICD Clinical Modification (ICD-9-CM), which modified the system for clinical and billing purposes, was one of the most significant advancements of ICD-9, especially in nations like the US (WHO, 2004; HCUP, 2010).

ICD-9-CM made it possible to classify illnesses, injuries, and treatments in far greater detail, which made the system very useful in clinical documentation, hospital settings, and insurance systems. This marked a significant change from a solely statistical tool to a dual-purpose system that supported administrative and therapeutic tasks.

Nevertheless, ICD-9 had significant drawbacks in addition to its enhanced utility and broad adoption. Due to its numerical limitations, the system was unable to handle newly discovered diseases and the quickly growing body of medical knowledge. Furthermore, its hierarchical structure occasionally lacked the flexibility needed for complicated clinical situations, which made it difficult to code consistently and accurately (O'Malley et al., 2005).

These restrictions made it clear that a more adaptable and scalable classification system was required, which ultimately resulted in the creation of ICD-10 and then ICD-11, which included digital compatibility and alphanumeric coding.

Table 1: Evolution of ICD Versions (ICD-1 to ICD-11)

ICD Version	Year	Key Features	Major Contribution	Limitations
ICD-1	1900	Mortality-based classification	First international standard system	No morbidity data
ICD-2-4	1910-1930s	Progressive refinements	Improved consistency	Limited authority
ICD-5	1938	Expanded categories	Better statistical detail	Still mortality-focused
ICD-6	1948	WHO control begins	Mortality + morbidity inclusion	Transition challenges
ICD-10	1992	Alphanumeric system	Global standardization	Complexity
ICD-11	2018	Digital ontology system	EHR integration	Implementation ongoing

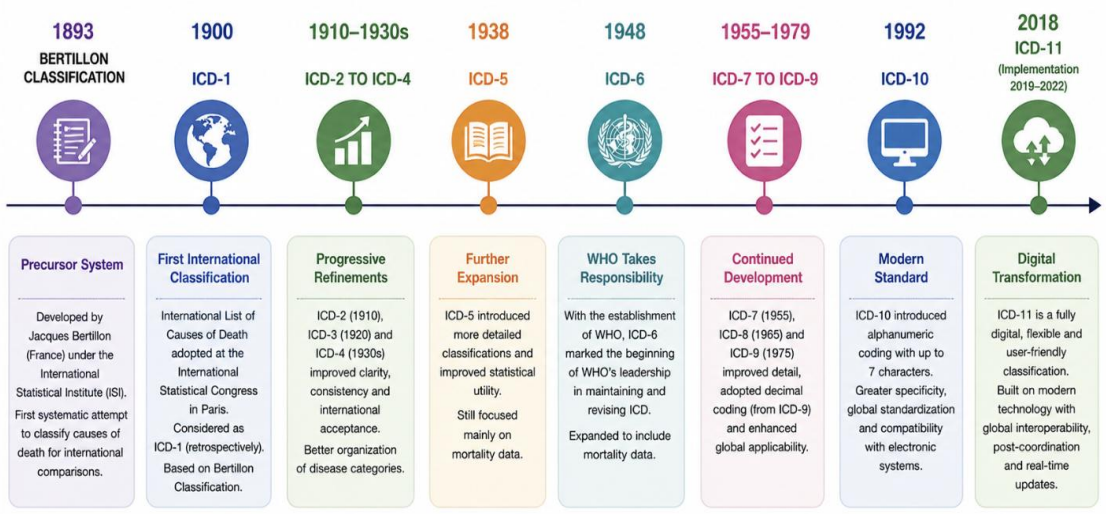

Figure 1: Timeline of ICD Evolution (ICD-1 to ICD-11)

4. ICD-10: A Major Milestone

One of the most important turning points in the development of international health classification systems is the Tenth Revision of the International Classification of Diseases (ICD-10). ICD-10, which was created under the World Health Organization's (WHO) supervision and formally approved in 1990, represented a significant shift from previous numeric-based systems to a more adaptable and comprehensive alphanumeric coding framework. The need for better worldwide comparability in morbidity and mortality statistics, the globalization of health data, and the growing complexity of contemporary medicine all influenced its development (World Health Organization [WHO], 2004; WHO, 2019).

ICD-10 was created to overcome the shortcomings of ICD-9, including its limited ability to code new disorders and its limited flexibility. For many years, it was the foundation of health information systems in numerous nations and became the most extensively used ICD version worldwide.

4.1 Introduction and Global Implementation

After considerable international cooperation and consultation with specialists in clinical medicine, epidemiology, and health statistics, ICD-10 was released. The revision process started in the late 1980s and ended with its publication in 1992. During the 1990s and early 2000s, it was progressively implemented worldwide.

ICD-10's widespread acceptance and adoption—the majority of WHO member states switched to the system for national mortality and morbidity reporting—was one of its main advantages. According to Mathers et al. (2006) and Lopez et al. (2013), this widespread deployment greatly enhanced the comparability of health data across nations, allowing for

more accurate estimates of the global illness burden and supporting international health initiatives.

By standardizing disease reporting procedures and enhancing data quality for public health surveillance and policy planning, ICD-10 also significantly contributed to the strengthening of health information systems.

4.2 Structural Features

In both clinical and statistical contexts, ICD-10's functionality and usability were greatly improved by a number of key structural improvements.

Alphanumeric coding system

The introduction of an alphabetic coding system in place of ICD-9's strictly numeric structure was one of the most significant structural changes in ICD-10. At the three-character level, each code in ICD-10 consists of a letter and two digits; decimal extensions are available for further specificity. The system's coding capacity was significantly increased by this design, enabling a far greater number of disease categories and subcategories (WHO, 2004).

Chapter-based organization

Each of the 21 chapters that make up ICD-10 represents a distinct category of illnesses or ailments. The anatomical system, etiology, or illness type are the main categories used to organize these chapters. For instance, there are distinct chapters for circulatory system problems, neoplasms, infectious diseases, and mental and behavioral disorders. Both statisticians and doctors found the system easier to use thanks to this structured approach, which enhanced navigation, consistency, and logical grouping of comparable disorders (Bowker & Star, 1999; WHO, 2019).

4.3 Advantages

ICD-10 was a notable breakthrough in global health classification systems since it provided some noteworthy advantages over earlier iterations. Greater specificity was one of its main advantages, which was made possible by its enlarged coding structure and capacity to record intricate disease subtypes. As a result, clinical situations could be more accurately documented, enhancing medical record-keeping and diagnostic precision.Improved epidemiological tracking was another significant benefit since ICD-10 made it possible to analyze illness patterns, risk factors, and health outcomes in greater depth. At the national and international levels, this promoted improved tracking of public health trends and made it easier to create focused health interventions (Lopez et al., 2013; Mathers et al., 2006).

Furthermore, ICD-10 improved the international comparability of health data, which was essential for resource allocation, health policy planning, and studies on the worldwide burden

of disease. Large-scale comparative studies between nations and regions were made feasible by its uniform framework.

4.4 Limitations

Despite its major contributions, ICD-10 also had several important limitations that became increasingly evident over time.

Its intricacy in clinical use was one of its main drawbacks. Although more thorough, the new coding system also made it more challenging and time-consuming for medical personnel to accurately apply ICD-10. This occasionally resulted in inconsistent clinical documentation and coding errors, especially in areas with limited resources (O'Malley et al., 2005).

Its incomplete digital integration throughout development was another drawback. ICD-10 was first created for paper-based and early computer systems, but it was later modified for use in electronic health systems. ICD-11 with native digital architecture was developed as a result of the growing demand for a more technologically connected system as healthcare moved more and more toward digital platforms (WHO, 2019).

Furthermore, even while ICD-10's hierarchical structure was effective, it occasionally lacked flexibility for portraying complicated or multifactorial illnesses, necessitating the use of more sophisticated modeling techniques in contemporary clinical informatics.

5. Transition to ICD-11

A significant paradigm shift in disease classification has occurred with the switch from ICD-10 to ICD-11, which reflects the quick development of digital health technology, contemporary clinical informatics, and the growing need for real-time, interoperable health data systems. ICD-11, the most extensive update in the ICD system's history, was created by the World Health Organization (WHO) and formally issued in 2018. It went into effect in 2022. In contrast to earlier iterations, ICD-11 was created as a completely digital, constantly updated classification system in order to meet the demands of modern global health (World Health Organization [WHO], 2019; Reed et al., 2019).

The realization that ICD-10, despite its widespread popularity, was no longer adequate to satisfy the needs of contemporary healthcare systems, which increasingly depend on electronic health records, precision medicine, and data-driven decision-making, was the driving force behind this shift.

5.1 Need for Revision

The need for ICD-11 emerged primarily due to two major factors: the rapid transformation of digital health systems and inherent limitations within ICD-10.

The creation, storage, and analysis of health data have all been profoundly altered by the shift to digital health. A classification system that could easily interface with digital platforms was necessary due to the increased use of electronic health records (EHRs), artificial intelligence in healthcare, and global health informatics systems. Due to its pre-digital architecture, ICD-10 lacked native digital functionality, which made adaption increasingly ineffective (WHO, 2019; Harrison et al., 2021).

Additionally, over time, a number of ICD-10's shortcomings became increasingly apparent. These included challenges in capturing new diseases and changing medical knowledge, coding complexity, and restricted flexibility in describing multi-dimensional clinical situations. A more dynamic system was required since ICD-10's inflexible hierarchical structure limited its adaptability in cutting-edge clinical and research applications.

5.2 Development Process

The World Health Organization spearheaded a highly cooperative international effort to develop ICD-11, which involved considerable consultation with doctors, epidemiologists, statisticians, health informaticians, and policymakers worldwide. Over ten years of field testing, expert reviews, and international feedback loops were all part of the modification process.

ICD-11's inclusive stakeholder involvement approach, which guaranteed input from a variety of users, including healthcare providers, coding experts, researchers, and health ministries, was one of its distinguishing characteristics. The system's usability, therapeutic relevance, and worldwide application were all intended to be enhanced by this participatory approach (Reed et al., 2019; WHO, 2019).In order to ensure that ICD-11 would operate as a fully electronic system rather than a digitalized version of a paper-based classification, the development process also placed a strong emphasis on digital-first design principles.

5.3 Key Features of ICD-11

Compared to ICD-10, ICD-11 offered a number of revolutionary structural and functional enhancements. One of its most significant characteristics is that it is a completely digital classification system that can be utilized via integrated software tools and web platforms. This makes it much more versatile than earlier iterations by enabling ongoing modifications without necessitating total system overhauls (WHO, 2019).

The Foundation Component, which acts as an extensive knowledge base with all ICD entities and relationships, is another important component. Depending on particular use cases, several linearizations (such as mortality and morbidity classifications) can be constructed from this foundation.

Additionally, an improved coding structure with longer and more adaptable alphanumeric codes was established by ICD-11. This enlarged structure greatly reduces coding uncertainty by enabling more specificity and better representation of complex clinical situations.

Additionally, by more closely matching actual clinical operations, ICD-11 enhanced clinical integration and usability. According to Harrison et al. (2021) and WHO (2019), the system was made to be more user-friendly for medical practitioners, which would lessen the coding burden and increase clinical documentation accuracy.

5.4 Innovations in ICD-11

ICD-11 introduced several innovative concepts that distinguish it from all previous versions.

The post-coordination system, which enables the combination of several codes to more accurately depict a single clinical condition, is one significant innovation. This makes it possible to depict complicated diseases more accurately without using an excessive amount of pre-defined codes.

Its ontology-based structure, which arranges medical concepts in a relational and hierarchical framework, is another significant development. This makes data modeling more adaptable and enhances compatibility with cutting-edge health informatics systems.

Additionally, ICD-11 facilitates smooth integration with electronic health records (EHRs), allowing for better data capture, automated coding, and increased interoperability across healthcare systems. In addition to supporting clinical decision support systems, community health monitoring, and real-time health analytics, this integration greatly enhances data quality (Reed et al., 2019; McKenzie et al., 2020).

6. Comparison Between ICD-10 and ICD-11

A major change in worldwide health classification systems, the switch from ICD-10 to ICD-11 reflects developments in digital technology, health informatics, and medical science. ICD-11 was created to remedy ICD-10's structural and functional shortcomings, especially in light of contemporary electronic health ecosystems, even though ICD-10 was a reliable and extensively used system for many years. Significant advances in structure, flexibility, usability, and global health applications are highlighted by a methodical comparison of the two versions (World Health Organization [WHO], 2019; Reed et al., 2019).

Structural Differences

The 21 chapters of ICD-10 are arranged mainly by body systems and illness categories and are based on a set alphanumeric hierarchical structure. Every code has a strict format that restricts growth and flexibility. In contrast, diseases and conditions can now be represented as

interconnected entities rather than fixed categories according to ICD-11's entirely digital and relational structure, which is based on a centralized Foundation Component.

ICD-11 may now more dynamically represent medical knowledge because to this structural change, which also lessens classification redundancy. A significant modernization of illness classification systems is represented by the transition from a static hierarchy (ICD-10) to a flexible ontology-based framework (ICD-11) (WHO, 2019; Harrison et al., 2021).

Coding Flexibility

Complex clinical diseases are frequently difficult to completely express due to ICD-10's relatively restricted coding system, which assigns a single number or a limited combination to each illness. In some circumstances, this may result in decreased specificity and loss of clinical information.

On the other hand, ICD-11 introduces post-coordination, which enables the combination of multiple codes to provide a more detailed description of a single illness. This offers far more versatility in depicting the anatomical location, origin, severity of the disease, and related problems. Consequently, ICD-11 provides a more accurate and flexible classification system appropriate for contemporary clinical practice (Reed et al., 2019).

Clinical Usability

ICD-10 is sometimes regarded as complicated and time-consuming in terms of clinical applicability, especially in high-volume healthcare settings. Its strict structure and lengthy code lists might make it more difficult for medical coders and doctors, which can occasionally result in inconsistent documentation.

On the other hand, ICD-11 was created with clinical workflow integration in mind. It has better alignment with clinical language, easier-to-use coding tools, and enhanced search capabilities. This improves overall documentation quality and clinical efficiency by making it easier for medical practitioners to understand and lowering coding errors (Harrison et al., 2021; WHO, 2019).

Digital Compatibility

Digital compatibility is one of the biggest distinctions between ICD-10 and ICD-11. ICD-10's integration with contemporary health technologies was constrained because it was first created in a pre-digital period and then modified for electronic systems.

In contrast, ICD-11 is a native digital classification system that can be easily integrated with digital coding platforms, health information systems, and electronic health records (EHRs). Real-time updates, automated coding support, and global healthcare system interoperability

are all supported. A significant development in health informatics infrastructure is this digital-first design (WHO, 2019; McKenzie et al., 2020).

Public Health Impact

ICD-10 made it possible for standardized epidemiological tracking across nations and greatly enhanced worldwide illness reporting. However, its efficacy in advanced public health analytics was limited by issues with specificity and digital integration.

By facilitating more accurate disease monitoring, greater burden of disease estimation, and increased connection with international health surveillance systems, ICD-11 improves the impact on public health. Its adaptable framework facilitates quicker and more efficient public health interventions by enabling more accurate capture of newly developing diseases and changing health conditions (Lopez et al., 2013; WHO, 2019).

In general, ICD-11 offers a more solid basis than ICD-10 for data-driven healthcare planning, global health monitoring, and evidence-based policymaking.

Table 2: Comparison of ICD-10 and ICD-11

Feature	ICD-10	ICD-11
Structure	Fixed hierarchical	Ontology-based digital system
Coding System	Alphanumeric, limited flexibility	Longer, flexible, modular codes
Usability	Complex for clinicians	User-friendly, clinical-oriented
Digital Integration	Limited	Fully digital (EHR compatible)
Updating System	Periodic revisions	Continuous updates
Clinical Detail	Moderate	High specificity (post-coordination)
Interoperability	Limited	High global interoperability

7. Applications of ICD System

A key international standard for classifying illnesses, medical disorders, and reasons of mortality is the International Classification of Diseases (ICD). Its function has grown significantly over time, surpassing mortality statistics to become an essential part of contemporary healthcare systems, clinical documentation, epidemiological research, health economics, and global health governance. Uniformity, comparability, and interoperability of health data across nations and healthcare settings are made possible by the extensive use of ICD (World Health Organization [WHO], 2019; Mathers et al., 2006).

7.1 Epidemiology and Disease Surveillance

Epidemiology and illness surveillance are two of the ICD system's most significant uses. Researchers and public health officials may track disease patterns, incidence, prevalence, and changes throughout time thanks to ICD's standardized framework for documenting illnesses and medical disorders.

ICD facilitates the identification of epidemics, newly developing infectious diseases, and shifting patterns of chronic illnesses by allowing consistent disease classification. It is essential to international surveillance systems, assisting agencies like the World Health Organization in monitoring diseases including COVID-19, diabetes, malaria, and tuberculosis. In order to provide trustworthy epidemiological data and promote evidence-based public health actions, this standardized methodology is crucial (Lopez et al., 2013; WHO, 2019).

7.2 Health Management and Policy Making

ICD is also frequently utilized in policy-making and health management, where it offers vital information for resource allocation and planning. ICD-coded data is used by governments and health organizations to prioritize healthcare services, comprehend population health needs, and create national health policies.

The system assists policymakers in determining disease loads, assessing the effectiveness of healthcare, and allocating funds to priority areas including maternity health, infectious diseases, and non-communicable diseases. A crucial tool for strategic health planning at the national and worldwide levels, ICD-based data is widely utilized in burden of illness studies and global health initiatives (Murray & Lopez, 2013; WHO, 2019).

7.3 Clinical Documentation

ICD is crucial for diagnostic coding and medical record documentation in clinical practice. It offers a standardized vocabulary that enables medical practitioners to document patient diagnoses in a uniform and widely comprehensible manner.

This uniformity facilitates accurate patient record-keeping, strengthens continuity of treatment, and promotes communication between healthcare professionals. Hospitals and healthcare systems frequently employ ICD codes to record illnesses, comorbidities, and clinical results. The implementation of ICD-11 has improved the quality and usability of clinical documentation by making it more exact and integrating it with digital health systems (Harrison et al., 2021; WHO, 2019).

7.4 Insurance and Billing Systems

ICD is also widely used in health insurance and medical billing systems. ICD codes are used to categorize diagnoses and calculate healthcare service reimbursement. Standardized ICD

coding is used by insurance companies to process claims, determine medical necessity, and guarantee that healthcare providers are paid appropriately.

ICD-10 and its clinical versions (like ICD-10-CM) are directly incorporated into billing systems in several nations. This guarantees openness, lowers fraud, and boosts healthcare financing effectiveness. Through enhanced digital integration and automated coding systems, ICD-11 is anticipated to substantially simplify billing procedures (O'Malley et al., 2005; WHO, 2022).

7.5 Global Health Reporting

International comparisons of health data and global health reporting depend heavily on ICD. ICD-coded data is used by the World Health Organization (WHO) and other international organizations to track illness burden, create global health statistics, and assess progress toward health-related objectives like the Sustainable Development Goals (SDGs).

Because ICD is standardized, reporting can be uniform across nations, making it possible to compare mortality and morbidity patterns accurately on a global scale. Global health surveillance, multinational research partnerships, and policy development all depend on this. Large-scale research like the Global Burden of illness (GBD) study, which mainly uses standardized illness classification to estimate health consequences internationally, is also supported by ICD (Lopez et al., 2013; WHO, 2019).

Table 3: Applications of ICD System in Healthcare

Application Area	Role of ICD	Impact
Epidemiology	Disease tracking & surveillance	Identifies trends & outbreaks
Health Policy	Health planning & resource allocation	Evidence-based decision making
Clinical Documentation	Standard diagnosis coding	Improves medical records
Insurance Systems	Billing & reimbursement	Reduces fraud, improves accuracy
Global Reporting	International health statistics	Enables global comparisons

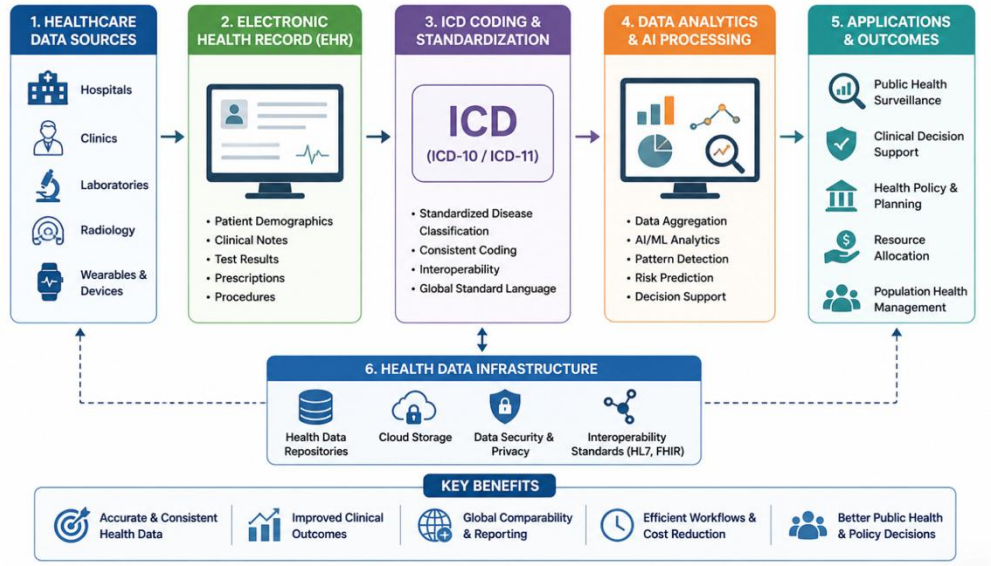

Figure 2: ICD Integration in Modern Digital Health System

8. Challenges in ICD Implementation

The International Classification of Diseases (ICD) presents a number of practical, technological, and systemic obstacles despite its crucial role in standardizing global health data. Depending on infrastructure, labor capacity, and digital readiness, these issues differ greatly throughout healthcare systems and become more noticeable during version transitions (e.g., ICD-10 to ICD-11). Improving the efficacy and worldwide uptake of ICD-based health information systems requires an understanding of these obstacles (World Health Organization [WHO], 2019; Harrison et al., 2021).

9. Future Perspectives

The future of the International Classification of Diseases (ICD) is closely linked with the rapid advancement of digital health technologies, artificial intelligence (AI), and global health data integration systems. As healthcare systems become increasingly data-driven, ICD is expected to evolve from a static classification framework into a dynamic, continuously updated knowledge system that supports real-time clinical decision-making, population health monitoring, and predictive analytics. A key development in this direction is the deeper integration of ICD-11 with digital health ecosystems, including electronic health records (EHRs), hospital information systems, and global health databases. Since ICD-11 is designed as a native digital platform, future enhancements are expected to further improve interoperability and enable seamless data exchange across healthcare systems worldwide (WHO, 2023; HIMSS, 2022).

Another major area of advancement is the integration of artificial intelligence and machine learning into ICD coding processes. AI-based systems are increasingly being developed to

automate disease classification, reduce human error, and improve coding efficiency by analyzing clinical narratives and assigning accurate ICD codes in real time. This is expected to significantly reduce the administrative burden on healthcare professionals while improving data accuracy and consistency. In addition, ICD is likely to evolve into an ontology-based system that connects diseases with genetic information, environmental factors, treatment outcomes, and social determinants of health, enabling a more comprehensive representation of human health beyond traditional classification methods (Shickel et al., 2018; Bodenreider, 2008; Rajkomar et al., 2019).

Furthermore, future ICD systems are expected to play a crucial role in strengthening global health surveillance and ensuring greater equity in health data reporting. With improved digital integration, ICD-coded data will enable near real-time monitoring of disease outbreaks, antimicrobial resistance, and chronic disease trends, thereby enhancing global preparedness for public health emergencies. Efforts by WHO are also focused on improving accessibility and reducing disparities in low- and middle-income countries through cloud-based platforms, simplified tools, and open-access resources. This will ensure more uniform adoption of ICD-11 and contribute to more complete, accurate, and globally representative health data systems (World Bank, 2021; WHO, 2023).

10. Conclusion

Over the course of more than a century, the International Classification of Diseases (ICD) has developed from a straightforward listing system based on mortality to a comprehensive and internationally defined framework for the recording, analysis, and reporting of health data. The system has consistently grown in terms of structure, specificity, and clinical significance, beginning with early classification efforts like the Bertillon system and continuing through subsequent modifications from ICD-1 to ICD-11. Every update made it easier to classify illnesses consistently and made it possible to compare health statistics between nations more effectivelyWith its totally digital architecture, flexible coding structure, and increased interface with contemporary healthcare systems, ICD-11 marks a substantial shift, whereas ICD-10 marked a considerable advancement with improved coding detail and widespread global use. Despite its extensive use, obstacles like resource constraints, system transition problems, and training needs still persist, especially in poor nations. However, it is anticipated that continued developments in artificial intelligence, digital health, and international standardization initiatives will reinforce its application even more. All things considered, ICD continues to be a vital component of global health information systems,

supporting worldwide health monitoring, epidemiological research, disease classification, and the creation of health policies.

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12. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this review.

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