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ORIGINAL RESEARCH

Analyzing the Creation and Use of Abbreviations in Cardiology and Cardiac Imaging Society Guidelines

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ABSTRACT

BACKGROUND Abbreviation use in clinical and academic cardiology is widespread, yet there are few guidelines regulating the creation and utilization of abbreviations. Inconsistent abbreviations can introduce ambiguity and pose challenges to practice and research.

OBJECTIVES The authors aimed to analyze how abbreviations are created and utilized in general cardiology and cardiac imaging society guidelines in order to assess whether ambiguities and discrepancies exist between societies.

METHODS Abbreviation data were collected from 7 national and international societies of general cardiology and cardiac imaging over a 6-year span (2018-2023). Data were linguistically coded for abbreviation type, unique occurrence, meaning or sense count, and frequency of discrepancy between societies.

RESULTS Among a total of 5,394 abbreviation tokens, there were 1,782 unique entries. Among the unique entries, 227 (12.7%) had 2 or more associated meanings (senses), and thus were potentially ambiguous. Cardiac societies differed from each other, and also internally, in their use of abbreviations, with the European Society of Cardiology representing the highest frequency of discrepant abbreviation usage (14.5%).

CONCLUSIONS More than 12.7% of abbreviations in cardiology society guidelines had 2 or more corresponding meanings, potentially increasing the risks of miscommunication and misrepresentation. We call on cardiology and cardiac imaging societies to define and publish best practices regarding abbreviation creation and utilization.

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ABBREVIATIONS AND ACRONYMS

ACC = American College of Cardiology

AHA = American Heart Association

ESC = European Society of Cardiology

SCMR = Society of Cardiovascular Magnetic Resonance

Abbreviation is a cover term for any shortened form of a word or phrase,[1] or the process of word formation whose aim is to simplify a string of words. In the clinical arena and medical discourse, abbreviation use is widespread, but studies have long warned of the dangers that they entail, in part because their use is variable and inconsistent.[2,3] Some have argued against the "compulsive" use of abbreviations and other acronyms, noting that even when policies are provided for abbreviation use, they are seldom followed by authors or enforced by editors.[4] Individuals, agencies, and professional and/or academic societies often adopt different strategies to form abbreviations, scarcely considering whether and how they have been employed elsewhere. As a result, abbreviations and their associated meanings often overlap, sometimes within and across populations of users, leading to ambiguities and discrepancies.

How, when, and by whom abbreviations are used, however, is consequential. Depending on the scenario, the aforementioned variation may, at the very least, result in confusion. There are also reports of more concerning outcomes in clinical practice. A 2007 report by the Joint Commission on Accreditation of Healthcare Organization claims that "nearly 5% of all medical errors (are) attributable to inappropriate use of acronyms and abbreviations."[5] These outcomes are ascribed in part to the fact that "interpretation of acronyms in medical note(s) is dependent on the knowledge and expertise of the person reading it."[6] Others concur, stating that abbreviations used in medical record keeping are "frequently misinterpreted."[7] In the clinical domain, widespread use of abbreviations is "frequently ambiguous and present(s) a problem for subsequent information retrieval" in electronic record keeping systems and "potentially can lead to patient safety issues."[8] Compounding this issue is that abbreviations used in different parts of the world, by different professional societies, and in different medical specialties often differ markedly from 1 another, and their varied use may contribute to patients' misunderstanding of their own medical records.[9]

Given these potential outcomes, societies and professional organizations have increasingly made available compiled lists of *sense inventories*,[10,11] cataloging abbreviations and associated meanings of current use. As with any database, however, there are inherent shortcomings of these sense inventories, such as the composition of the originating sources, and relatedly, the fact that there is no guarantee the inventory is complete. Furthermore, inventories do not necessarily provide an evaluation of the terms, nor a recommendation of best practices. Defining guidelines, and ensuring that they are implemented, is left to individual societies and editors, though this too is fraught with challenges.

To assess the pervasiveness of abbreviation use and its potential to create ambiguities and discrepancies, particularly within the context of cardiology, this study reports detailed findings concerning the use of abbreviations of different types, as gathered from guidelines from 7 national and international societies of general cardiology and cardiac imaging over a 6-year span (2018-2023).

METHODS

Given several of the authors' subspecialty in echocardiography, we selected representative societies from both general cardiology and cardiac imaging with the intention to include well-known societies within the cardiology community (**Table 1**). The general cardiology societies included were American College of Cardiology (ACC), American Heart Association (AHA), and European Society of Cardiology (ESC), and the cardiac imaging societies were American Society of Echocardiography, American Society of Nuclear Cardiology, Society of Cardiovascular Computed Tomography, and Society of Cardiovascular Magnetic Resonance (SCMR). We selected a 6-year timespan from 2018 to 2023 to generate a representative pool of recent years' abbreviation usage.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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TABLE 1 Number of Guidelines and Abbreviation Tokens From Cardiac Societies

Society Abbreviation[a]	Number of Guidelines	Number of Abbreviation Tokens
ACC	13	493
AHA	13	485
ASE	24	688
ASNC	12	89
ESC	22	2,762
SCCT	20	470
SCMR	10	407
Total	**114**	**5,394**

We gathered a total of 114 practice guideline documents from the 7 cardiology and cardiac imaging societies from 2018 to 2023. Abbreviations were gathered either directly from the guideline documents' published lists of abbreviations or by our manual extraction from the document. Our initial gathering rendered 5,904 potential abbreviations, from which 15 were excluded (eg, those starting with special characters, complete phrases, etc), arriving at a total of 5,394 abbreviation tokens.

[a]Society Abbreviation: ACC = American College of Cardiology; AHA = American Heart Association; ASE = American Society of Echocardiography; ASNC = American Society of Nuclear Cardiology; ESC = European Society of Cardiology; SCCT = Society of Cardiovascular Computed Tomography; SCMR = Society of Cardiovascular Magnetic Resonance.

We then compiled each society's guidelines published within this time frame from their guideline databases; the only exception was for AHA, which had multiple publication types (guidelines, scientific statements, health policy statements, etc.) and duplicative publications for the same content (full guideline, executive summary). Therefore, for AHA guidelines, a title search for "clinical practice guidelines" was applied to its publication database, and only full guidelines were selected. Within each guideline, abbreviations were extracted by 2 methods: 1) if a guideline had a published list of abbreviations, this list was transferred verbatim to our database; and 2) if a guideline did not have an existing list of abbreviations, we manually extracted abbreviations utilized in the texts, tables, and figures of the guideline. Institutional Review Board approval was not needed for our research as it did not involve any human or animal subjects. We utilized only descriptive statistics (range, percentage, distribution) in this study, rather than inferential statistics (hypothesis testing), as our goal in this exploratory study was to better understand how authors and guideline creators formed and used abbreviations. This, we hope, will raise awareness of current practices, how and where ambiguities have arisen, and in turn inform the development of new best practices.

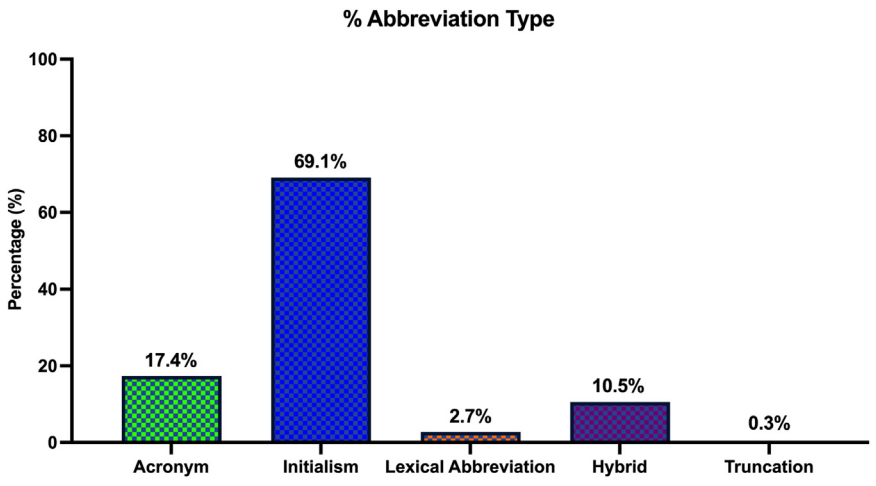
To better understand their composition, we applied linguistic coding to all abbreviations, including abbreviation types, number of associated meanings or senses, and finally, a tally of discrepancies in meanings or senses among cardiac societies. We coded abbreviations according to 5 abbreviation types—acronym, initialism, lexical abbreviation, hybrid, and truncation. The 2 largest categories—acronym and initialism—were further subdivided to better understand the details of their formation. Here we provide a brief overview of the characteristics of these abbreviation categories and the linguistic underpinnings that guided our coding methodology.

In the linguistic subfield of morphology, which concerns itself with word formation, abbreviations are typically divided into several categories, among them *acronyms*, *initialisms*, and *truncations*,[12] though there are other "neighboring" categories,[13,14] that have been proposed. Unlike other types of word formation, the study of abbreviations does not have a deep research tradition. In textbooks and other pedagogical resources, they are often relegated to a few passing words and examples.[15,16] More substantive discussion of abbreviations and related practices is encountered in translation studies and subtitling guidelines, and increasingly in computer science and natural language processing publications concerning their retrieval from texts and the challenges they present to word sense ambiguation,[17] including in clinical texts.[18]

For *acronyms*, the first letter of each of a string of words creates a new word form that can be pronounced as a single word; a well-known acronym is *PIN* "personal identification number." The fact that one does not pronounce *PIN* letter-by-letter, [P-I-N], but rather as a standalone word, [pɪn], is key to its status as an acronym. On the other hand, *initialisms* are formed by a similar strategy but pronounced letter-by-letter, such as *ATM* "automatic teller machine." Variation in an abbreviation's status as acronym vs initialism may occur, such as with *LOL*, which may equally be pronounced [L-O-L], or as a word [lahl]. Other strategies of abbreviation formation include *truncations* (aka *clippings*), which remove 1 or more syllables from a word, as in *prof* for "professor." The simplest abbreviations are "graphic" in nature,[12] like *p*. for "page," and so conventionalized that they scarcely merit explanation.

Our initial survey revealed that abbreviations are highly variable in the ways they are formed, thus requiring a finer-grained coding schema. While some abbreviations were "true" acronyms and "true" initialisms, in the prototypical senses defined above, other subtypes were observed. For example, it was often the case that 1 or more words were omitted in the formation of an abbreviation. This may involve

FIGURE 1 Percentages of Abbreviation Types Among Abbreviation Tokens Percentage Breakdown of All Five Abbreviation Types Among the 5,394 Abbreviation Tokens



Initialisms accounted for 69.1% (n = 3,725) of abbreviation tokens, acronyms 17.4% (n = 936), followed by hybrids 10.5% (n = 568), lexical abbreviations 2.7% (n = 148), and truncations 0.3% (n = 17).

omission of *function* (ie, grammatical) words, as 1 finds in *NBE* "National Board of Echocardiography," or also of *content* words, as in *RAC* "Radioactive Source Attenuation Correction." Abbreviations were also sometimes formed by selecting more than one letter from one or more component words, as in *CONCOR* "Congenital Corvitia," or even by forming a part-acronym-part-initialism *hybrid*, as in *RVAD* (R-vad), where 1 or more letters are pronounced separately. In the most extreme cases, "contrived acronyms"[19] are formed by often idiosyncratic, large-scale removal of words or parts of words in order to arrive at a recognizable and/or easily recallable word or mnemonic. Lastly, we noted some instances where abbreviations appear to have become so conventionalized that they have altogether lost association with their origins; 1 such example is *Qs* "systemic blood flow," whose *Q* derives from "quantity (of perfusion)." From a linguistic standpoint, 1 can say that these have become *lexicalized* in that they are unique entries in our collective vocabulary.

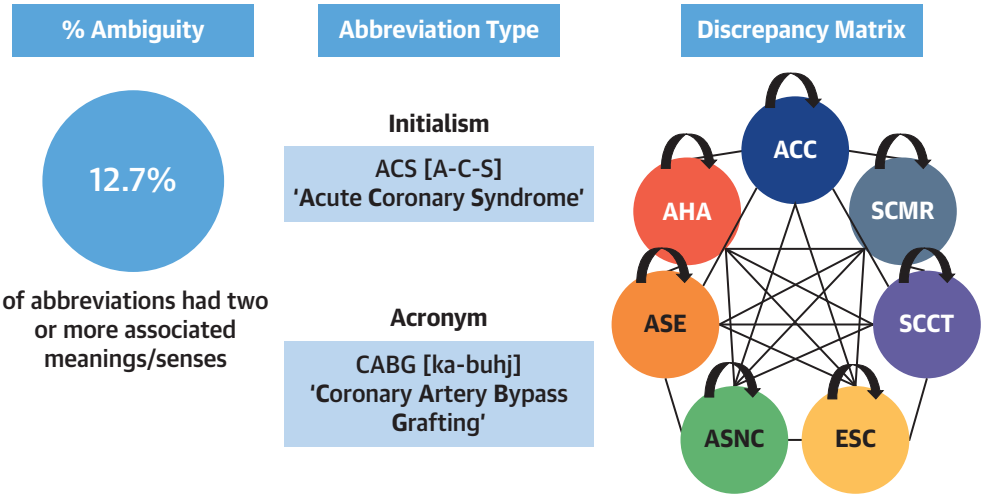
From the total number of abbreviation *tokens* (ie, occurrences), unique entries were identified and coded. For example, *WHO* "World Health Organization," appeared 5 times but was counted as 1 unique entry. From this list, we cataloged and tallied abbreviation-meaning pairs, or *senses*—all *WHO* entries had the *sense*, yielding a sense count of 1. *VA*, however, was variously defined across our database as "veno-arterial," "ventricular arrhythmia," and "ventriculoatrial," and accordingly, its sense count was 3. For each abbreviation with more than 1 sense, we tracked which societies differed from 1 another in using different senses of the same abbreviation. Each time a sense count was greater than 1, it was coded as an instance of discrepancy and tallied in a matrix fashion. The results of this tally are discussed below. See the Supplemental Appendix for a summary of technical definitions used in our analysis.

RESULTS

We gathered abbreviations from 114 practice guidelines from 7 societies across a 6-year timespan. This initial data yielded 5,409 potential abbreviation tokens; we excluded 15 of these that we did not consider abbreviations (eg, those starting with special characters, complete phrases, etc), leaving us with 5,394 abbreviations to be analyzed (**Table 1**). Based on coding for the 5 abbreviations categories defined above, percentages of tokens in each category are in **Figure 1**. Initialisms far outnumbered all other abbreviation types. Subcoding, as discussed below, reveals that their use is largely homogeneous while acronym creation is more diverse.

From the larger abbreviation set, we identified 1,782 unique abbreviations and coded their associated meanings/senses. Our results revealed that ambiguity was present in 12.7% (n = 227) of unique entries. That is, 12.7% of the 1,782 unique entries had more than

CENTRAL ILLUSTRATION **Linguistic Analysis of Abbreviations in Cardiac Society Guidelines**



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Sense counting revealed that 12.7% of abbreviations had two or more associated meanings or senses, creating ambiguity in their utilization. The two main types of abbreviations were initialism and acronym. Discrepancies of abbreviation utilization were tallied in matrix tables among and between cardiac societies.[a] [a]Society Abbreviation: ACC = American College of Cardiology; AHA = American Heart Association; ASE = American Society of Echocardiography; ASNC = American Society of Nuclear Cardiology; ESC = European Society of Cardiology; SCCT = Society of Cardiovascular Computed Tomography; SCMR = Society of Cardiovascular Magnetic Resonance.

1 associated sense, analogous to the example of *VA* mentioned above (**Central Illustration**). Breaking this down further, **Figure 2** shows that while 1,555 unique entries (87.2%) had just a single sense, 162 (9.0%) had 2 senses, 43 (2.4%) had 3 senses, and 13 (0.7%) had 4 senses. In the most extreme cases, we found 4 entries having 5 or more associated senses. Example (1) provides details of 1 particularly striking case of ambiguity pertaining to the abbreviation *CA*, for which we found 4 divergent senses represented in guidelines.

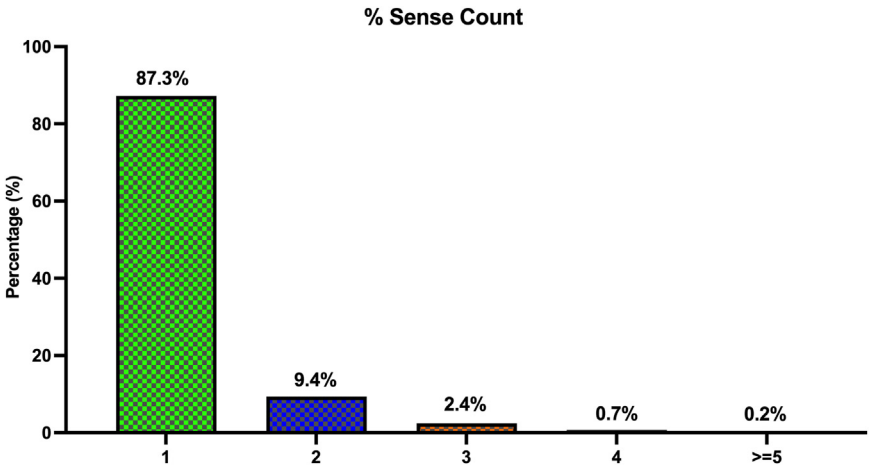
(1) 4 associated senses for *CA*
  (a) Coronary artery
  (b) Cardiac amyloidosis
  (c) Cardiac arrest
  (d) Competitive athletes

Table 2 provides a list of sample abbreviations that have more than 1 associated sense in our database, illustrating examples that could easily be misinterpreted or incorrectly employed in clinical practice and/or academic research. Lists like **Table 2** are often called *sense inventories*—several recent research studies have highlighted the importance of developing and maintaining sense inventories to aid in training computational algorithms for word-sense disambiguation, machine learning, natural language processing, and deep learning.[8,9,10,11]

In coding entries, we chose not to count certain types of discrepancies as ambiguous. For example, differences in typeset case (eg, *VKA*: "vitamin K antagonist" vs "Vitamin K antagonist"), punctuation (eg, *WCD*: "wearable cardioverter defibrillator" vs "wearable cardioverter-defibrillator"), number (singular vs plural, as in *PA*: "pulmonary artery" vs "pulmonary arteries"), and other minor divergences (eg, *T2DM*: "type 2 diabetes mellitus" vs "type II diabetes mellitus") were not counted as discrepant. If, however, we were to have coded such minor divergences (n = 49), the total percentage of ambiguities would increase from 12.7% to 15.5%.

Taking a closer look at common abbreviation types, especially among initialisms and acronyms, **Figure 3** shows that among 3,725 initialisms, "true" initialisms (defined above) accounted for 91.5% (n = 3,410) of all abbreviations of this type. A further 5.6% (n = 209) were formed by removing function words (eg, *ULN*: "upper limit of normal"), while 1.7% (n = 65) removed a content word and potentially 1 or more function words (eg, *VNC*: "virtual noncontrast image"). In 1.1% (n = 41) of instances, an initialism

FIGURE 2 Percentages of Sense Counts Among Unique Abbreviation Entries



Among the 1,782 unique abbreviations entries, the majority 87.3% (n = 1,555) had only one corresponding meaning (sense = 1), but a sizeable 12.7% (n = 227) had more than one corresponding meaning, reflecting the underlying risk of misrepresentation. Among them, 9.4% (n = 167) had sense = 2, 2.4% (n = 43) had sense = 3, 0.7% (n = 13) had sense = 4, and 0.2% (n = 4) had sense >= 5.

was "extended," being formed by letters beyond the first in each word (eg, *BrS*: "Brugada Syndrome").

The outcome is notably different for acronyms where among 936 abbreviations of this type, only 45.4% (n = 425) were "true." **Figure 4** shows the remaining 54.6% departed from the typical idea of acronym in various ways, having omitted function words (11.8%, n = 110; eg, *GRACE*: "Global Registry of Acute Coronary Events"), omitted content (and potentially function) words in (8.0%, n = 75; eg, *GAMI*: "Glucose Abnormalities in Patients with Myocardial Infarction"), or by being extended (7.2%, n = 67; eg, DiRECT "Diabetes Remission Clinical Trial").

In addition to the acronym types discussed thus far, 27.7% (n = 259) of acronyms in our sample were coded as idiosyncratic, "contrived" acronyms, many of which were names of conditions, treatments, procedures, and clinical trials. As an example, consider *ICONIC* "Incident Coronary Syndromes Identified by Computed Tomography." Here, to form the acronym (our interpretation), the creator chose letters that were either word-initial or interspersed within a word; other words, whether function or content, were omitted to arrive at the desired output.

The current study builds upon results introduced in other work[20] by more closely considering the details of discrepancies in abbreviation use across different societies. To begin, **Table 3** shows that general cardiology and cardiac imaging societies use a wide range of discrepant abbreviations and some do so more than others. Within our data set, there were 858 discrepant abbreviations used: while 73.9% (n = 634) occurred between different societies, 26.1% (n = 224) occurred within the same society. An example of intersociety discrepancy is *CE*, which was used as "cardiac event" by the ESC vs "contrast-enhanced" by the SCMR. An example of intra-society discrepancy is *TVR*, which was used as "target vessel revascularization" in 1 guideline from the ESC vs "tricuspid valve replacement or repair" in another ESC guideline. Our matrix tallying system captured both intersociety and intrasociety discrepancies—for each abbreviation entry with more than 1 sense, a tally entry was made for that specific pair of societies (eg, ESC-SCMR, ESC-ESC). Overall, the ESC-ESC intrasociety discrepancy represented the highest incidence of discrepant abbreviation use, accounting for 14.5% (n = 124) of all discrepant abbreviations. This is followed by ESC-ACC, which accounts for 8.4% (n = 72), and the ESC-AHA, which accounts for 8.2% (n = 70) of total discrepancies.

We also observed that among the 33 abbreviations in our sample with the most frequent occurrence (20 or more tokens), 18 (54.5%) had 2 or more associated senses across guidelines. The most frequently occurring abbreviation, *LV* (n = 63) had 3 associated senses—left ventricular, left ventricle, left ventricular/left ventricle (or reversed left ventricle/left ventricular). The second most frequently occurring

TABLE 2 Sample Abbreviations With More Than One Meaning or Sense

Abbreviation	Corresponding Meanings or Senses
AC	Arrhythmogenic cardiomyopathy
	Attenuation correction
	Anthracycline chemotherapy
AV	Aortic valve
	Arteriovenous
	Atrial-ventricular
	Atrioventricular
BAV	Balloon aortic valvuloplasty
	Bicuspid aortic valve
CA	Coronary artery
	Cardiac amyloidosis
	Cardiac arrest
	Competitive athletes
CHD	Congenital heart disease
	Coronary heart disease
CI	Cardiac index
	Confidence interval
CS	Coronary sinus
	Conscious sedation
	Cardiogenic shock
	Cancer survivors
DF	Diamond and Forrester score
	Diffuse fibrosis
DT	Deep transgastric
	Destination therapy
ERP	Early repolarization pattern
	Effective refractory period
HPS	Hepatopulmonary syndrome
	His-Purkinje system
ICA	Internal carotid artery
	Invasive coronary angiography
IE	Infective endocarditis
	Interventional echocardiography
LVV	Large vessel vasculitis
	Left ventricular volume
MI	Mechanical index
	Myocardial infarction
MRA	Magnetic resonance angiography
	Mineralocorticoid receptor antagonist
PA	Pulmonary artery
	Pulmonary atresia
	Physical activity
PPM	Patient-prosthesis mismatch
	Permanent pacemaker
PVR	Paravalvular regurgitation
	Pulmonary valve replacement
	Pulmonary vascular resistance
PW	Left ventricular posterior wall
	Pulsed-wave
RF	Radiofrequency
	Regurgitant fraction
SV	Single ventricle
	Stroke volume
TPR	Total pulmonary resistance
	Transmural perfusion ratio
	Transmyocardial perfusion ratio
VA	Ventriculoatrial
	Veno-arterial
	Ventricular arrhythmia

Continued in the next column

TABLE 2 Continued

This table demonstrates a sample list of abbreviations in the database that had more than 1 associated meaning or sense. These abbreviations can be seen in daily clinical practice and academic research; therefore, their multiple meanings create ambiguity in their utilization and interpretation.

abbreviation, *ECG* (n = 54) also had 3 associated senses—electrocardiogram, electrocardiography, and electrocardiographic. For the 78 abbreviations in our sample with 10 to 19 tokens, 37 (47.4%) had 2 or more associated senses. There were 142 abbreviations with 5 to 9 tokens, and among these 56 (39.4%) had 2 or more associated senses. Thus, it would appear that there is a general trend that likelihood of having discrepancy senses increases with token count.

DISCUSSION

Cardiology has been identified as a specialty with a relatively high percentage of abbreviation use in clinical practice, as compared to other medical specialties. Pottegård notes that acronym usage was present in 40% of studies in cardiology compared to 8 to 15% in 4 other specialties (endocrinology, pulmonary, rheumatology, psychiatry).[21] The trend of ever-present abbreviation utilization is especially pronounced in the naming of cardiac clinical trials in the past few decades.[2] An increasingly competitive journal publication landscape,[2,4,21] and perhaps even word count limitations required by publishers, may also have contributed to accelerating the adoption and proliferation of abbreviations. We offer some recommendations below concerning how societies might begin responding to the current, arguably unsustainable state of affairs.

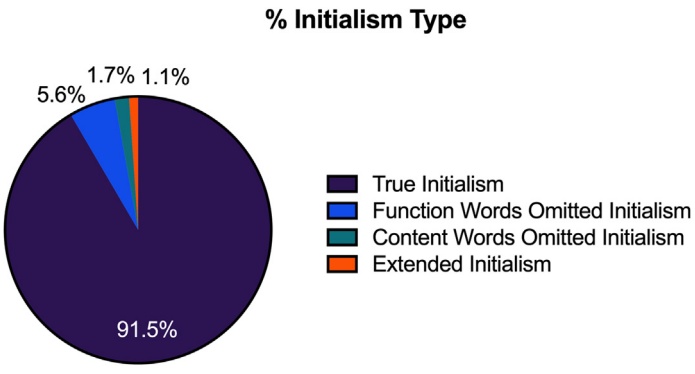
As above, we found that among 1,782 unique abbreviations, 12.7% had more than 1 corresponding meaning. Even though this means that the vast majority of abbreviation entries (87.3%) did not feature potential ambiguity, a 12.7% occurrence of ambiguity is troublesome enough. For example, *ELISA* could either represent the commonly known laboratory testing technique of “enzyme-linked immunosorbent assay,” or it could represent a clinical trial named “Early or Late Intervention in unStable Angina.”

Needless to say, such ambiguity can be confusing, if not risky, when utilized in clinical and research settings.

When comparing the discrepant usage of abbreviations across the 7 societies, we found that the ESC accounted for both the highest intrasociety and intersociety discrepancies. This is perhaps a reflection of the diverse composition of the ESC, which has 57 affiliated national cardiac societies across Europe and the Middle East.[22] Another possible explanation may correlate with the fact that ESC guidelines in our database contained more than one-half of the original abbreviation tokens (ie, the raw number of abbreviations with their extensions) as seen in Table 1 - the sheer number of abbreviations might have increased the chance of discrepant definitions.

One of the most telling insights gained from our analysis of abbreviation types is that while the vast majority of initialisms (91.5%) were "true" initialisms, less than half (45.4%) of acronyms were "true" acronyms. In other words, when guidelines provided initialism abbreviations, most adhered to the convention of utilizing only first letters to construct the abbreviation, which is to be pronounced letter-by-letter. However, less disciplined use of abbreviations occurred with regard to acronyms, where more variation can be observed. Among acronyms that were not "true" acronyms, 27.7% were "idiosyncratic" or "contrived" acronyms whose construction deviates far from the convention of utilizing first letters. This way of creating acronyms was observed for most clinical trial name abbreviations. Therefore, to exercise more discipline in abbreviation utilization, discouraging the use of idiosyncratic acronyms might be a good start.

FIGURE 3 Subcoding and Percentages of Initialisms



Among the 3,725 initialisms, the vast majority 91.5% (n = 3,410) were "True" initialisms where the abbreviations were generated from the first letters and were pronounced letter-by-letter. The remaining initialisms included 5.6% (n = 209) where function words were omitted, 1.7% (n = 65) where content words were omitted, and 1.1% (n = 41) where the initialisms were extended beyond the first letters.

There are several limitations to our study. First, our selection of 7 general cardiology and cardiac imaging societies was based primarily on the overall repute of the societies rather than on any algorithmic criteria. Similarly, the choice of a 6-year timespan (2018-2023) was more arbitrary than quantitative. Our objective was to perform a primary overview of the state of abbreviations in guideline writing, and therefore exhaustiveness was not 1 of our primary intentions. We acknowledge that such an approach limits the comprehensiveness of our abbreviation database. A future project could consider more closely into which societies should be included, and what criteria should be applied in determining the timespan of the guidelines searched. Second, when constructing the discrepancy matrix across societies, we did not stratify within the abbreviation types or subtypes, partly because the abbreviation type and the corresponding society do not necessarily "travel together" thus making a stratification challenging to interpret. For example, *CTA* has sense count of 3, including "computed tomographic angiography" (a true initialism, from ACC), "coronary computed tomography angiography" (a lexical initialism, from AHA), and "CT angiography" (a hybrid abbreviation, from Society of Cardiovascular Computed Tomography). Here, the 3 senses stem from 3 different abbreviation types and came from 3 different societies. Thus, it would be difficult to attribute which abbreviation type has caused the discrepancy of the *CTA* abbreviation. Third, our data analysis was limited to descriptive statistics such as counts and percentages without applying statistical significance testing. Given that our objective was not to exhaustively collect all abbreviations from all societies, an overapplication of significance analyses might have detracted from the primary purpose of this study which was to analyze the composition and current use of abbreviations, with the intention to inform the process of guideline creation in the future. While our study has focused on characterizing the linguistic composition of abbreviations, rather than analyzing the potential consequences of discrepant abbreviations in day-to-day clinical practice, we believe that future quantitative studies aimed at investigating the downstream impacts of abbreviation discrepancies on end users (eg, clinical providers, compliance officers, billing and coding administrative staff, insurance claims adjusters, research administrators, automated

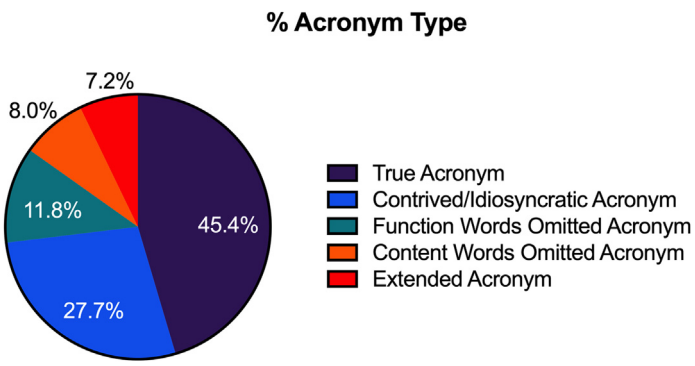
computational systems, etc), is justified and appropriate.

One might ask why we should concern ourselves with analyzing and dissecting how abbreviations are constructed, presented, and utilized by society guidelines. This is because, first, societies set the standard for how professional organizations and practitioners communicate with 1 another and with patients. Therefore, having standardization practices in nomenclature should be a prerequisite. Second, with the rapid advancement in machine learning and artificial intelligence technologies, it is imperative that training models be optimized (ie, with the existing body of literature and guidelines) so that the resultant algorithms can generate accurate and meaningful outcomes.[11] A number of societies have already recognized the importance of standardizing nomenclature in the setting of rapidly changing technologies, such as the cases of extracorporeal membrane oxygenation (ECMO) and cardiac computed tomography (cardiac CT).[23,24]

Because there is limited literature on how best to standardize abbreviations, 1 approach might be for societies to develop abbreviation guidelines and recommendations for their use based on expert consensus and awareness of how and where ambiguities arise in abbreviations. For example, in addition to discouraging or avoiding idiosyncratic acronyms, as mentioned above, strategies for disambiguation might be proposed—consider *AV*, which had 3 senses in our data set—aortic valve, arteriovenous, and atrioventricular. This could be alternatively disambiguated using an "extended" initialism employing 1 or more characters from word components, such as the alternatives *AoV*, *AVen*, and *AVent*, respectively. We hope that ultimately arriving at such a consensus will be facilitated by the observational data and findings provided herein.

In sum, we believe that the time is right for cardiology and cardiac imaging societies to begin taking steps to set standards for the creation and utilization of abbreviations. First, we call on societies to begin taking steps to establish consensus on what abbreviations to use. This would require consortium building among different cardiology and cardiac imaging societies and the creation of task forces within and across societies to set international standards for abbreviation use in cardiology research. Second, we encourage early adoption of and experimentation with machine learning technologies to detect, decipher, and cross-reference abbreviations, with the goal to eliminate inaccurate interpretation. Third, and more aspirationally, we would advocate for the creation and open-source hosting of a central sense inventory for abbreviations across disciplines so that clinicians and nonclinicians alike can access and utilize a common database. It is our hope that these steps might provide a roadmap for future endeavors in abbreviation standardization.

FIGURE 4 Subcoding and Percentages of Acronyms



Acronyms (n = 936) had more heterogeneity in their subcategories. Only 45.4% (n = 425) were "True" acronyms where the abbreviations were generated by the first letters and were pronounced as single words. Notably, 27.7% (n = 259) were contrived or idiosyncratic acronyms where the construction of the abbreviations deviated from convention. Among the rest, 11.8% (n = 110) omitted function words, 8.0% (n = 75) omitted content words, 7.2% (n = 67) extended beyond first letters.

TABLE 3 Incidence and Percentage of Discrepant Abbreviations Across Cardiac Societies

Society Pair[a]	Discrepancy Incidence (Percentage)	Society Pair	Discrepancy Incidence (Percentage)
ACC-ACC	17 (2.0%)	ASE-ASNC	9 (1.0%)
ACC-AHA	18 (2.1%)	ASE-ESC	61 (7.1%)
ACC-ASE	34 (4.0%)	ASE-SCCT	34 (4.0%)
ACC-ASNC	7 (0.8%)	ASE-SCMR	32 (3.7%)
ACC-ESC	72 (8.4%)	ASNC-ASNC	3 (0.3%)
ACC-SCCT	25 (2.9%)	ASNC-ESC	16 (1.9%)
ACC-SCMR	25 (2.9%)	ASNC-SCCT	8 (0.9%)
AHA-AHA	15 (1.7%)	ASNC-SCMR	7 (0.8%)
AHA-ASE	34 (4.0%)	ESC-ESC	124 (14.5%)
AHA-ASNC	6 (0.7%)	ESC-SCCT	56 (6.5%)
AHA-ESC	70 (8.2%)	ESC-SCMR	46 (5.4%)
AHA-SCCT	24 (2.8%)	SCCT-SCCT	22 (2.6%)
AHA-SCMR	25 (2.9%)	SCCT-SCMR	25 (2.9%)
ASE-ASE	29 (3.4%)	SCMR-SCMR	14 (1.6%)

Each cell represents a pair of cardiac societies from which we tallied the incidence and percentage of discrepant abbreviation use. There were a total of 858 incidences of discrepant abbreviation utilization, among them 73.9% (n = 634) occurred between different societies, and 26.1% (n = 224) occurred among the same societies. The ESC-ESC intrasociety represented the most frequent discrepant abbreviation utilization with 124 incidences (14.5%) of all discrepancy occurrences.

[a]Society Abbreviations: ACC = American College of Cardiology; AHA = American Heart Association; ASE = American Society of Echocardiography; ASNC = American Society of Nuclear Cardiology; ESC = European Society of Cardiology; SCCT = Society of Cardiovascular Computed Tomography; SCMR = Society of Cardiovascular Magnetic Resonance.

CONCLUSIONS

Abbreviations from 114 guideline documents published by 7 cardiology and cardiac imaging societies were reviewed corresponding to the span of 2018 and 2023. Overall, there was 12.7% ambiguity in their definitions. Societies also differed widely in how abbreviations were defined, with the ESC representing the most frequent incidences of discrepancies compared to other societies. We call on cardiology and cardiac imaging societies to define best practices for abbreviation creation and use, in order to standardize nomenclature for clinical practice guidelines and clinical research. Doing so promises to have broader implications not only for clinicians and researchers, but for patients, informaticists, compliance and regulatory administrators, and the next generation of medical students and trainees.

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PERSPECTIVES

COMPETENCY IN SYSTEMS-BASED PRACTICE: Language and nomenclature are at the core of safe and effective clinical care. Abbreviations are currently defined and utilized in nonuniform ways even among society guidelines, presenting potential risks for clinical care and scholarly research that may ultimately impact overall quality of medical care.

TRANSLATIONAL OUTLOOK: Better standardization of abbreviation nomenclature would pave the way for advanced algorithms in machine learning and artificial intelligence should these technologies need to be deployed for future practice and research.

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KEY WORDS **abbreviation, initialism, acronym, linguistic coding, cardiology society guideline**

APPENDIX **For a summary of linguistic terms used in analysis, please see the online version of this paper.**