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The Ambiguous Medical Abbreviation (AMA) Study - Challenges and Opportunities

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Background: Healthcare workers often abbreviate for convenience, but ambiguous abbreviations may cause miscommunication, which jeopardises patient care. Robust large-scale research to quantify abbreviation frequency and ambiguity in medical documents is lacking.

Aims: To calculate the frequency of abbreviations used in discharge summaries, the proportion of these abbreviations that are ambiguous and the potential utility of auto-expansion software.

Methods: We designed a software program to extract all instances of abbreviations from every General Medical Unit discharge summary from the Royal Melbourne Hospital in 2015. We manually expanded abbreviations using published inventories and clinical experience, logging multiple expansions for any abbreviation if identified. Abbreviations were classified based on well-defined criteria as standardised and likely to be well-understood, or ambiguous. Outcome measures included the range and frequency of standardised and ambiguous abbreviations, and the feasibility of electronic auto-expansion software based on these measures.

Results: Of the 1,551,537 words analysed from 2,336 documents, 137,997 (8.9%) were abbreviations with 1,741 distinct abbreviations identified. Most abbreviations (88.7%) had a single expansion. The most common abbreviation was PO (per os/orally), followed by BD (bis in die/twice daily), and 68.1% of abbreviations were standardised, largely pertaining to pathology/chemicals. This meant, however, that a large proportion (31.9%) of abbreviations (2.8% of all words) were ambiguous. The most common ambiguous abbreviation was Pt (patient/physiotherapy), followed by LFT (liver function test/lung function test).

Conclusions: Close to one-third of abbreviations used in general medical discharge summaries were ambiguous. Electronic auto-expansion of ambiguous abbreviations is likely to reduce miscommunication and improve patient safety.

Key words: Abbreviations (D020463), Electronic Health Records (D057286), Patient Safety (D061214), Interprofessional Relations (D007400), Medical Records (D008499).

1 Introduction

Despite advances in communication technology, documentation remains a time-consuming element of clinical care. Doctors are expected to complete significant paperwork, such as inpatient progress notes, operation reports, discharge summaries, outpatient letters, and referrals to other practitioners. A 2015 Malaysian survey of doctors and nurses identified time saving, avoidance of writing sentences in full and convenience as the key drivers to abbreviate.[1] Survey participants agreed that abbreviations were a 'necessary and an acceptable' part of working in hospitals.

Unfortunately, abbreviation-based miscommunication is common. In one survey of abbreviation comprehension among more than 200 healthcare professionals, the correct meaning was identified for only 43% of items.[2] Beyond mere confusion, misinterpretation of abbreviations may lead to inappropriate, delayed or even deleterious patient care. A US-based 2001 Sentinel Event Alert found that up to 5% of prescription-related errors could be attributed to abbreviations.[3] A 2012 Australian survey of inpatient prescribing found that 8.4% of orders contained at least one error-prone abbreviation, with 29.6% of these deemed to be high risk for causing significant harm.[4]

Eliminating abbreviations entirely from medical communication is unattainable and counterproductive. Certain standardised medical abbreviations are, for practical purposes, universally used and understood, and should be permitted in medical documentation. These include pathology tests and *système internationale* (SI) units. Abbreviations with multiple expansions are ambiguous without sufficient context (e.g. MS: multiple sclerosis/mitral

stenosis) and should thus be written in full, as should abbreviations requiring local knowledge to understand (e.g. MU1, Medical Unit 1).

A novel solution to abbreviation-based miscommunication is the use of auto-expansion software. This is particularly attractive given the widespread transition to electronic medical records (EMRs). Upon typing an ambiguous abbreviation, the software would automatically expand it, or request user permission to do so. The clinician benefits from efficiency of input while the reader benefits from enhanced comprehension.

Discharge summaries represent an especially risky context for abbreviation-based miscommunication. The purpose of a discharge summary is to succinctly document a patient's hospital care. Abbreviation allows each document, whose content often spans multiple medical and surgical domains, to be brief. However, recipients such as community healthcare providers may not be familiar with all abbreviations, but are expected to provide ongoing patient care based on this document's content. The largest study of abbreviation use to date reviewed 200 discharge summaries and identified 321 unique abbreviations, but since word counts were not obtained, abbreviation frequency was unable to be calculated.[5] Only one study has attempted to ascertain the frequency of abbreviations: Politis et al analysed abbreviation use in 80 general medical discharge summaries from a large tertiary Australian hospital (The Royal Melbourne Hospital).[6] They found that approximately one in five words (20.1%) was an abbreviation, but the generalisability of these findings is uncertain given the study's small sample size.

In the present study, we sought to calculate the frequency of abbreviations used in in all general medical discharge summaries from the Royal Melbourne Hospital for one calendar year (2015) and the proportion of these abbreviations that were ambiguous. Auto-expansion software could clarify these ambiguous abbreviations, offering a novel solution to minimise abbreviation-based miscommunication in the era of the EMR.

2 Methods

We designed a software program written in the Python language (Python Software Foundation, Delaware, USA) to extract all instances of abbreviations from every general medical discharge summary written at the Royal Melbourne Hospital in 2015. A total of 2,336 summaries containing 1,551,537 words were analysed.

The program detected abbreviations by considering every word in every discharge summary, then rejecting or including words based on four criteria (Box 1). The resulting categorised words were reviewed by researchers to confirm correct categorisation.

Box 1- Selection criteria used to extract abbreviations

1. Exclusion: words located in a document template-generated line, as these do not contribute to variable abbreviation burden (e.g. hospital address appearing as a footer on all discharge summaries)
2. Exclusion: words containing any lowercase alphabetic characters, as these represent normal words (e.g. pneumonia, home)
3. Exclusion: words with fewer than two or more than six characters in length, as words of these lengths are unlikely to be abbreviations (e.g. Y, thyroid)
4. Inclusion: words appearing on institution's 'approved abbreviation' inventory†, as these represent abbreviations that may be erroneously excluded by criterion two (e.g. abdo, sats)

†1,388 abbreviations condoned by the institution's Health Information Services

Substantively similar abbreviations were combined (e.g. BSL, BSLs). Researchers manually expanded abbreviations using Stedman's Medical Dictionary[7], Another Database of Abbreviations in Medline (ADAM)[8], internet search engines, and clinical experience. Any abbreviations with multiple possible expansions had all of these logged (e.g. LAD, left axis deviation/left anterior descending [artery]).

Researchers then independently identified 'standardised' abbreviations: abbreviations with single expansions and whose meaning would not be enhanced by expansion. Only those abbreviations unanimously deemed standardised and appearing in both Stedman's Medical Dictionary and ADAM were finalised as such.

Standardised abbreviations fell into one of ten well-defined categories: common English expressions (e.g. ASAP, as soon as possible), pharmacology (e.g. PO, per os), pathology/chemicals (e.g. FBE, full blood examination), SI units/measurements (e.g. cm, centimetres), anatomy/physiology (e.g. T10, tenth thoracic vertebra), tests/procedures/devices known by abbreviations (e.g. CT, computerised tomography), drugs known by abbreviations (e.g. GTN, glyceryl trinitrate), diseases known by abbreviations (e.g. GORD, gastro-oesophageal reflux disease), people/places/organisations known by abbreviations (e.g. ICU, intensive care unit), and typographical errors (e.g. KNDA instead of NKDA, no known drug allergy). Typographical errors were categorised as 'standardised' by virtue of the inherent difficulties in attempting to auto-expand these errors.

These standardised abbreviations were removed. The remaining abbreviations were labelled 'ambiguous': non-standardised abbreviations whose meaning would be clearer if written in full. The frequency and characteristics of these abbreviations were then re-analysed.

Ethics approval was granted by the Human Research Ethics Committee of the Royal Melbourne Hospital as a quality assurance project.

3 Results

A total of 2,336 discharge summaries were analysed. Of the 1,551,537 words analysed,137,997 (8.9%) were abbreviations. A total of 1,807 different abbreviations were identified. After grouping substantively similar abbreviations (e.g. BSL and BSLs), 1,741 distinct abbreviations were identified (Figure 1).

Multiple expansions were identified for 197 distinct abbreviations (197/1,741; 11.3%) totalling 12,896 instances. Most (147/197, 74.6%) had two expansions, 40 (20.3%) had three and 10 (5.1%) had four. The remaining abbreviations could be assigned a single expansion.

Discharge summaries contained an average of 59.1 abbreviations (137,997/2,336; range 3-117, 1.3% of all words and 20.6% of all words respectively). The most common abbreviation was PO (*per os*/orally), followed by BD (*bis in die*/twice daily) and GP (general practitioner) (Figure 2). Of the top 100 most commonly used abbreviations, the majority related to pathology/chemicals (30%), followed equally (12% each) by diseases/symptoms, investigations, and units/measurements.

Most abbreviations (68.1%, 93,913/137,997) were standardised. The majority of standardised abbreviations pertained to pathology/chemicals (28,357) and pharmacology (27,326) (Table 1). The remaining abbreviations (31.9% of abbreviations [44,084/137,997] and 2.8% (44,084/1,551,537) of all words) were ambiguous. Most of these ambiguous abbreviations (84.8%; 1,096/1,293) had a single expansion. The most common ambiguous abbreviation was Pt (patient/physiotherapy), followed by LFT (liver function test/lung function test) and AF (atrial fibrillation/atrial flutter) (Figure 3). Only four of the top 100 abbreviations were site-

specific (i.e. RMH [Royal Melbourne Hospital], MU1 [medical unit 1], MU2 [medical unit 2] and GEM [Geriatric Evaluation and Management {subacute care medical unit}]).

Using auto-expand software the writer would experience auto-expansion of ambiguous abbreviations every 35 words and would be prompted for clarification (due to multiple possible expansions) every 120 words. With the average summary being 664 words long, auto-expansion would occur approximately 19 times per summary and 5.5 of these would require writer clarification.

4 Discussion

With over 1.5 million words analysed, our study is the largest analysis of abbreviations in discharge summaries to date. Of concern, we found that 8.9% of all words are abbreviations and nearly one third of these are ambiguous. Safety interventions should target these abbreviations to maximise the comprehensibility of discharge summaries for optimal patient care. We propose a novel solution in the form of software to automatically expand these ambiguous abbreviations.

Our data reveal the scale of potential abbreviation-based miscommunication in discharge summaries for the first time. Discharge summaries are crucial communication tools among healthcare providers. Confusing abbreviations cloud correspondence and may jeopardise timely, accurate patient care. With 9% of all words in discharge summaries being abbreviations, and 3% of all words being ambiguous abbreviations, the risk of miscommunication is dangerously high. In light of our findings, interventions to reduce ambiguous abbreviation use must be prioritised to ensure patient safety.

Auto-expand software would appropriately place the onus for clarifying abbreviation meaning on the writer, rather than the recipient, while allowing the productivity benefits of abbreviation use. Context is not appreciated by auto-expand software, but context does not necessarily correlate with comprehensibility. Previous research found that orthopaedic surgeons could correctly state the expanded form of just over half (57.2%) of in-context abbreviations used in orthopaedic inpatient notes.[9]

We found that the majority of ambiguous abbreviations (84.8%) had a single expansion and thus would be readily amenable to auto-expansion without any effort or interruption for the writer. For the remaining small proportion of ambiguous abbreviations with multiple expansions, the writer could be prompted with a dropdown menu of options (e.g. 'did you mean rheumatoid arthritis, right atrium, or something else?') with the ability to personalise the behaviour of the software (e.g. a cardiologist may set the latter option as the default expansion).

Site-specific abbreviations accounted for only a small fraction of abbreviations, but carry a high risk of misunderstanding outside the local setting. Long periods of employment at one healthcare service may inure the writer to the site-specificity of certain abbreviations. As patients increasingly move between health services, states or countries, the universal comprehensibility of medical documentation is paramount for continuity of care. Institutions could easily tailor auto-expand software to target site-specific abbreviations, instantly eliminating them from documentation and removing this barrier to optimal patient care.

Limitations

We acknowledge the inherent subjectivity in manually expanding abbreviations or deeming an abbreviation 'standardised' or 'ambiguous'. Given our significant collective clinical experience, and requirements for both unanimous researcher categorisation and abbreviation

inclusion in multiple internationally validated inventories, we feel that our categorisation method was as valid as practically achievable.

Our abbreviation-extracting software enabled an unprecedented number of documents to be analysed, but it removed the manual process of reading abbreviations in context. Some abbreviations may have been erroneously expanded to an extant medical term, but if read in context, may not reflect the author's intended meaning. Any abbreviations with multiple expansions, such as in this scenario, had all expansions recorded; lack of context did not affect the completeness of our inventory. Further, we maintain that an abbreviation with multiple expansions is by virtue ambiguous and ought to be written in full, regardless of context.

Our study was conducted at a single academic tertiary hospital: other institutions may have different patterns of abbreviation use. Finally, assessing the impact of abbreviation use on patient care was beyond the scope of this study and would be a valuable area of future research.

5 Conclusion

Abbreviations assist the writer, yet may confuse the recipient and jeopardise patient care through miscommunication. Our study, the largest ever analysis of abbreviation use in discharge summaries, highlights the concerning high frequency of ambiguous abbreviations and proposes novel auto-expand software as a feasible possible solution to improve patient safety and post-discharge care.

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7 Figure legends

Figure 1- Flowchart of abbreviation extraction and removal of standardised abbreviations

Figure 2- Top ten most common abbreviations

Data label key: Abbreviation (expansion), total instances [n=137,997], proportion of top ten most common abbreviations (%) [n=35,389]

Figure 3- Top ten most common ambiguous abbreviations

Data label key: Abbreviation (expansion), total instances [n=44,084], proportion of top ten most common ambiguous abbreviations (%) [n=10,508]

8 Tables

Table 1- Categories, number and frequency of standardised abbreviations, and examples

Category	Number of abbreviations	Total instances of abbreviations (n=137,997)	Examples
Not abbreviations/common English	63	5,050	ASAP, III
Pharmacology	31	27,326	BD, PRN
Pathology/chemicals	126	28,357	WBC, MgSO4
Units/measurements	42	9,104	mmHg, CFU/L
Anatomy/physiology	89	1,547	L3, T4
Tests/procedures/devices known by abbreviations	41	10,834	TOE, CABG

Typos	24	80	NTEMI (instead of NSTEMI, NHYA (instead of NYHA)
Diseases known by abbreviations	11	4774	GORD, TB
Drugs known by abbreviations	10	692	PPI, SSRI
People/places/organisations known by abbreviations	11	6,149	ICU, GP

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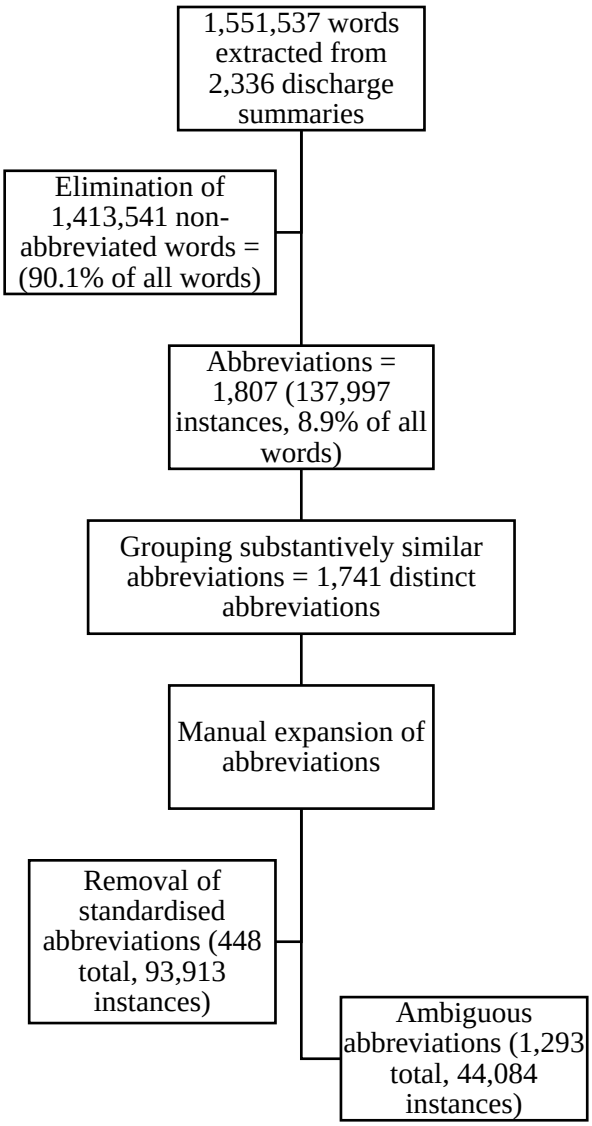

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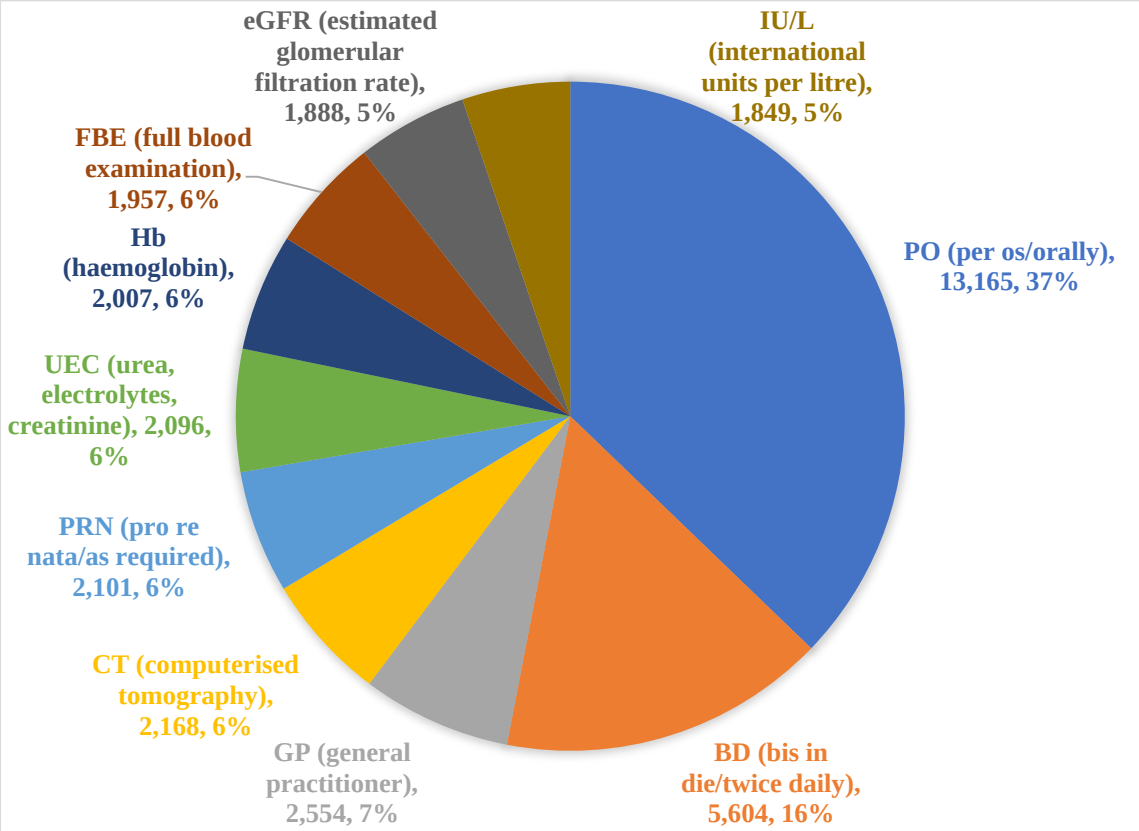

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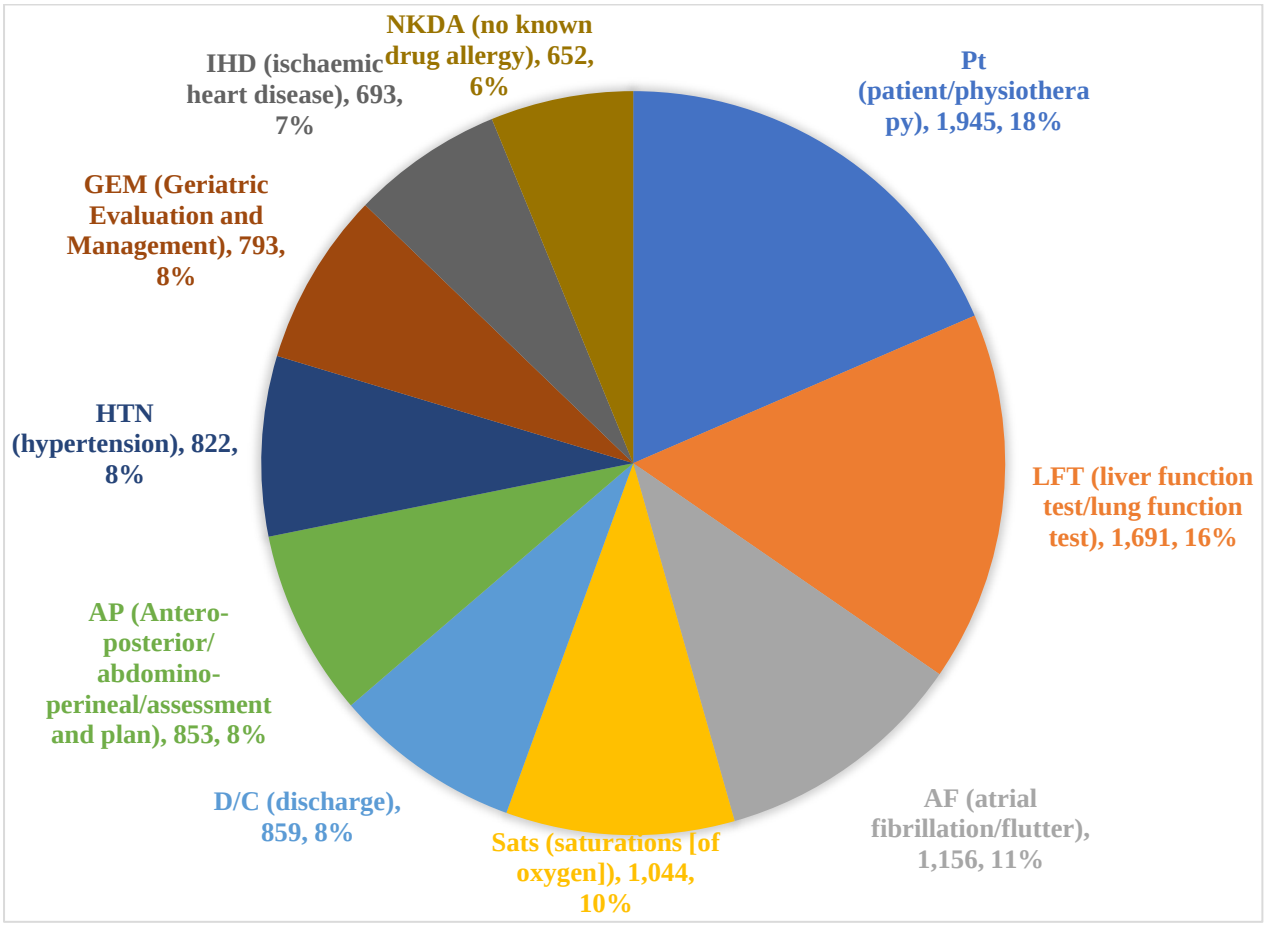

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