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| RESEARCH ARTICLE

Vowel Pronunciation Errors in English Biomedical Terminology by Arab Healthcare Professionals

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| ABSTRACT

This study aimed to identify the kinds of vowel pronunciation errors made by Arab healthcare professionals such as doctors, dentists, pharmacists, physical therapists, nutritionists, lab technicians, radiologists and others. Additionally, the study aimed to find out whether the mispronounced vowels in biomedical terms are interlingual, intralingual, or developmental. A sample of 75 biomedical terms with mispronounced vowels was collected from the spontaneous speech of 52 Arab healthcare professionals. 45% of the participants work at pharmacies in Riyadh, 5 hospitals and polyclinics and 55% are YouTubers with healthcare channels on YouTube. Data analysis showed that the subjects make a variety of vowel mispronunciations such as pronouncing terms with y & i as /ai/ in (acetyl, methyl, vertigo, cervical) as in the letter name in the English alphabet, relate them to analyze, overgeneralize the pronunciation of i in combine to combination, pronounce the suffix -gia in neuralgia & metatarsalgia orthographically as /dʒjə/ instead of /dʒə/. They also lengthen "-in", "-on" & "-ol" ending to /iːn/, /ɔːn/ & /ɔːl/ in Aspirin, Melatonin, Insulin, Relaxon, Parafon, Pantozol due to Arabic phonetic tendencies, overcorrection & by analogy with caffeine. /eu/ in Euthyrox and Eucarbon is pronounced /ʊ/ not /yʊ/. By contrast the eu in Neuroton is pronounced /ju/ or /jʊ/ instead of /ʊ/ or /u/. In diet, the triphthong /ˈdaɪ.ət/ or /ˈdaɪ.ɪt/ is reduced to the diphthong /ai/ (/daɪt/). The vowels a, e, o in Galvus, Omega & Mobic are shortened. They changed the vowel in "Rapidus," "Centrum," "Maximum," from /ə/ sound (schwa) to /ʊ/ due to Arabic phonotactic influence. Vowel mispronunciations can be attributed to orthographic influence (cervical), overgeneralization from related words (combine), overgeneralization of familiar patterns to new biomedical terms as the analogy between amylase and analyze and applying phonological interference, leading to vowel shifts. Further examples of vowel pronunciation errors, the strategies used in pronouncing them, and whether the errors are interlingual, intralingual, or developmental are described. Recommendations for vowel pronunciation improvement for healthcare students, faculty and professionals are given as well.

| KEYWORDS

Vowel pronunciation, vowel errors, biomedical terms, Arab healthcare professionals, vowel shortening, vowel lengthening, orthographic influence, Arabic phonotactics, phonological interference, letter name strategy

| ARTICLE INFORMATION

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1. Introduction

English biomedical terminology is a specialized vocabulary used in healthcare as anatomy, physiology, pathology, pharmacy, nursing, dentistry, symptoms and signs, clinical procedures and others as (*homeostasis, metabolism, appendicitis, osteoporosis, hypertension, gastroscopy, biopsy, venipuncture, analgesic, antibiotic, dyspnoea, oedema, cyanosis*). These biomedical terms consist of Greek and Latin roots with prefixes and suffixes, making them structurally different from non-general specialized English vocabulary. English biomedical terminology is especially challenging for students in the healthcare field due to linguistic factors as: (i) Manyy medical English terms are borrowed from Latin and Greek, therefore non-native English students struggle with their complex structure that consists of prefixes, suffixes, roots and combining forms to create long, multi-syllabic words (*gastroenterology*, *pancytopenia, electroencephalogram*). (ii) Many medical terms contain unfamiliar vowel combinations, difficult

consonant combinations, silent letters, and unpredictable stress placement, making pronunciation harder: *amoeba, anomia, haemorrhage, diarrheal, radii, vertebrae, phlegm* (with silent g), *rheumatoid* (silent h), *pneumonia* (silent p), *colonoscopy* (stress on the third syllable), and *febrile /ˈfiːbrəl/*, not */ˈfɛbrɪl/* defy standard English phonics. (iii) A variety of Latin plurals forms exist as (*radius>radii, appendix>appendices, vertebra>vertebrae, bacillus> bacilli, fungus>fungi, alga>algae, bacterium bacteria, analysis>analyses, hypothesis>hypotheses, phenomenon>phenomena*). (iv) Some terms sound or look similar but have different meanings, causing confusion as *Ileum* (part of the intestine) & *Ilium* (hip bone).

Due to the complexity of biomedical terms, the pronunciation problems that biomedical terms pose for students and professionals in the healthcare fields have been the focus of numerous studies in the literature. For example, in the USA, Diamond, et al. (2023) developed a Medical Oral Language Proficiency Assessment (MOLPA) tool to assess medical oral language proficiency of immigrant doctors from Asia and Latin America Asia in USA. The doctors' common errors included stress shifts (*appendicitis* /æpɛnˈdɪsaɪtɪs/) and consonant clusters (*splenomegaly* /spliːnoˈmɛgəli/). Non-native accents disproportionately affected perceived competence. *Splenomegaly* simplification from /spliːnoʊˈmɛgəli/ to /spliːnoˈmɛgəli/ was noted in their MOLPA validation data. Mispronunciations of vowel sounds and medical jargon often led to communication breakdowns between doctors and patients. In another study, Chiu et al. (2017) detected non-native accent gaps in medical conversations (*metastasis* /ˈmɛtəsteɪsɪs/) which hindered accuracy.

In a third study in the USA, Horani (1995) examined how the pronunciation of non-native-English-speaking physicians from different ethnic backgrounds: American, Japanese, and Persian, affected medical-surgical nurses' perception of their competence. Results indicated a significant positive correlation between a physician's pronunciation and nurses' perceptions of his medical competence. The physician with the strongest accent, i.e., the native Japanese-speaker, received the lowest ratings. Findings showed that mispronunciations related to diagnoses and medication orders, led to decreased confidence among nurses regarding the physician's expertise. Vowel substitutions (lesion /ˈliːʒən/ /ˈlɛʒən/) led to perceptions of lower competence. Syllable reduction (dehydration /dihaɪˈdreɪʃən/) made miscommunication worse. Horani (1995) concluded that if a physician's pronunciation or speech style causes nurses to evaluate him negatively, there is a need for pronunciation and accent reduction instruction in the EFL classroom and in continuing English language instruction for non-native-speaking hospital staff in teaching hospitals, and for cross-cultural training that target nurses.

In Indonesia, Maharani et al. (2020) analysed recordings of pronunciation errors by 100 Indonesian medical students. The results revealed that the most frequent errors were diphthong reductions (*pneumonia* /njuːˈmɒniə/) and silent-letter errors (*psychiatry* /psɪˈkaɪətri/). Additionally, Ulinuha et al. (2024) analyzed recordings of 50 Indonesian students majoring in hospital administration. It was found that spelling-induced errors as *syringe* /ˈsaɪrɪndʒ/ disrupted procurement workflow.

In Iran, 200 students in Iranian Medical Education received stress-rule instruction. The pre- and post-test results showed improvement in lexical stress (*biopsy* /baɪˈɒpsi/) as a result of stress-rule instruction, enhancing patient comprehension (Meymeh & Khadembashi, 2015). In another study, group-based pronunciation tasks and cooperative learning with 90 Iranian medical students were carried out by Sanaee et al. (2013). Confusion errors of /w/-/v/ as in (*ventricle* /ˈwɛntrɪkəl/) were reduced by 40% as a result of peer correction.

In Europe, results of pronunciation tests with 120 first/second-year Serbian medical students at Novi Sad University showed stress-pattern (abdomen /æbˈdoʊmɛn/) and consonant substitutions errors (*venous* /ˈvɛnəs/) were systematic (Marošan & Marković (2010). Similarly, an Open Educational Resources (OER) pilot study with 70 Spanish medical students revealed that syllable-timing interference errors (*carcinoma* /karˈsiːnoːma/) improved with rhythmic exercises (Bellés-Fortuño & Bellés-Calvera (2017). In Slovakia, medical and dentistry students struggled with vowel length, stress misplacement in multisyllabic terms (e.g., *hypertension*, *appendicitis*), vowel reduction errors, especially in unstressed syllables, and consonant cluster simplification (e.g., dropping /s/ or /t/ in clusters). There were L1 interference caused /θ/ > /t/ substitutions as in (*therapy* /ˈtɛrəpi/) and final-consonant deletion (*joint* /dʒɔɪn/). Common stress and intonation issues affected intelligibility of Latin-derived medical terms. The students improved as a result of receiving explicit instruction on English stress-timing (Hamar, 2024).

In Japan, Kawashima (2018) conducted a quasi-experimental study with 60 nursing students using visual pronunciation guides in the form of a Pronunciation Table for Medical Terms. The /l/ & /r/ confusing errors as in *allergy* /ˈærədʒi/ and vowel-length errors as in *colon* /kɒˈlɒn/ decreased by 23% as a result of using the table.

In India, Mani et al. (2020) analyzed 1,000 clinician-patient dialogues using Automatic Speech Recognition (ASR) error correction for medical conversations. They found homophone errors (*ileum* vs. *ilium*) which required context-awareness algorithms.

Regarding the pronunciation errors produced by Arab medical students and healthcare professionals, few studies in the literature were found. In India, Khan & Salam (2019) explored oral communication barriers for Arab medical students in Indian medical schools). Interviews and pronunciation tests with 80 students revealed vowel epenthesis (*sclerosis* /sɪklɪˈroʊsɪs/) and stress shifts (*anemia* /ˈænɪmiə/). The most frequent errors involved vowel elongation, incorrect stress placement, and confusion between voiced and voiceless consonants. As a result, clinical interactions suffered due to unintelligibility. In Egypt, surveys and audio recordings of 30 medical faculty teaching in English at Egyptian universities demonstrated that the medical teaching staff lacked knowledge and use of the supra-segmental features of pronunciation, such as word stress, intonation, rhythm, timing, and pause. They also struggled with vowel reductions (*patella* /pəˈtɛlə/>/pæˈtellə/) and stress errors (‘*diagnosis* stressed on first syllable). Mispronunciations caused confusion on the part of students, especially in terms like (*ischemia* /ɪˈskiːmiə/ > /aɪˈskiːmiə/) (Albaaly, 2022).

The literature revealed lack of studies that investigate healthcare students and professionals’ errors in pronouncing vowels in biomedical terms. Therefore, this study aims to identify the kinds of vowel pronunciation errors produced by Arab healthcare professionals such as doctors, dentists, pharmacists, physical therapists, nutritionists, lab technicians, radiologists and others. Additionally, the study aims to find out whether the mispronounced vowels in biomedical terms are interlingual, intralingual or developmental.

This study emphasizes the importance of accurate pronunciation of vowels in biomedical terms for establishing healthcare students and professionals’ authority and professionalism. Mispronunciation of vowels in biomedical terminology can lead to and cause confusion in medical settings, breakdown in doctor-patient communication, especially among non-native English speakers, affect precision in treatment recommendations, and serious misunderstandings in diagnoses, and treatment plans. Mispronunciations may cause ambiguity in professional discussions between non-native healthcare professionals and English-speaking peers, and may lead to misinterpretation in medical documentation, affecting research and patients’ records. They may lead to lower confidence in non-native speaking healthcare participants in international medical conferences and research presentations. Correct pronunciation of vowels is a mark of professionalism and education, especially in medicine where precision matters. It enhances healthcare professionals’ credibility and ensures effective communication with colleagues and patients. Healthcare professionals who speak clearly are perceived as more reliable, competent and knowledgeable.

2. Methodology

2.1 Participants

Participants in the current study consisted of 52 healthcare professionals including medical doctors, pharmacists, physical therapists, nutritionists, dermatologists, lab technicians, radiologists, health administrators and others. 55% of the participants work at pharmacies in Riyadh, and 5 hospitals and polyclinics and 45% are YouTubers with healthcare channels on YouTube. The healthcare professionals in the sample are all Arab, they speak with the patients and the general public or followers in Arabic but occasionally insert English biomedical terms as names of medications and diseases. All the participants studied in English in college. Non-Arab healthcare professionals were excluded.

2.2 The Vowel Error Corpus

A sample of 75 biomedical terms with mispronounced vowels was collected from the spontaneous speech of Arab healthcare professionals who are studying or have studied medicine, dentistry, pharmacy, nutrition, radiology, physical therapy, nursing and others in English as a foreign language. The author collected the pronunciation errors from observations of the participants in natural conversational situations, whether the participants were speaking in Arabic and code-switching (mixing Arabic discourse with English words) or they were fully speaking in English. In collecting the data, the author used the diary methodology. Only errors in pronouncing vowels in English biomedical terms were recorded. The set of biomedical terms with faulty vowels and how the vowels are pronounced by each subject was recorded together with a transcription of their faulty pronunciation. No tests, questionnaire surveys, or interviews were used. The participants were not prompted or given any stimuli to produce biomedical terms with mispronounced vowels.

2.3 Data Analysis

The biomedical terms in the sample were sorted out and grouped according to the type of mispronounced vowel as follows:

- Acetyl, amylase, amyloid, methyl,
- Allicin, vertigo, cervical, pica, amino acid, alpha lipoic acid.
- Alkali, combination, Braille, plantar fasciites,
- Neuralgia, metatarsalgia, myalgia, arthralgia, cephalalgia
- Febrile, sterile, fragile.

- Aspirin, melanin, melatonin, insulin, amoxicillin, haemoglobin, penicillin, serotonin, Nurofen, Eucerin, Bilirubin, Augmentin, erythromycin, Degasin, Dizinil, Ivarin, Colpermin, Duspatalin, Fucidin, Bilaxten, *Hespredin*, diosmin, Reparil, Perfectil, Amaryl, Chlorophil,-Diaoptim,
- Relaxon, Parafon, Pharmaton, Avalon, Pantozol
- Euthyrox, Eucarbon
- Neurological, Tuberculosis, Neuroton, Neurobion
- Galvus Met, Mobic, Omega
- Rapidus, Centrum, maximum, minimum, memory, serum
- Nivea, Diet, Humalog, wear and tear

The pronunciation of each term was verified by Google Translate and Copilot. Terms that have two variant pronunciations in a consonant as *plantar fasciitis* /ˈplæntɑːr fæʃiˈaɪtɪs/ or /ˈplæntɚ ˌfæsiˈaɪtɪs/ were included but the analysis focused on the vowel not consonant pronunciation. But Terms that have two variant pronunciations in the vowel were excluded as *lipoprotein* /laɪpoʊproʊtiːn/ or /lɪpoʊproʊtiːn/, *lipo* /ˈlaɪpoʊ/ or /ˈlɪpoʊ/ and *cysteine* /ˈsɪstiːn/ or /ˈsɪsteɪn/. The standard pronunciation of each term in the sample was transcribe by Copilot and Gemini AI using the International Phonetic Alphabet (IPA), whereas the author transcribed the participants' pronunciation using the International Phonetic Alphabet (IPA) symbols. Results of the analysis are reported qualitatively. The percentage of participants who mispronounced the vowel in each word was not calculated as what matters in this study is the kind of vowel error, not the frequency of participants producing each errors.

The sources of vowel pronunciation errors were classified into (i) interlingual errors that refer to L1 interference, i.e., those transferred from the speakers' native language; (ii) intralingual errors, i.e., those arising from within the target language (L2), such as overgeneralization or incomplete rule application, and (iii) developmental errors, i.e., those reflecting stages in language acquisition, often shared by both L1 and L2 learners.

3. Results

The vowel error data analysis revealed that Arab healthcare professionals in the current study mispronounce the vowels in the following biomedical terms as follows:

1) The participants pronounced y in *Acetyl, Amylase, Amyloid*, *methyl* as /aɪ/. This can be attributed to faulty grapheme-phoneme correspondence knowledge, where Arab healthcare professionals tend to pronounce *y* using the letter name strategy, i.e., like the letter name in the English alphabet, where *y* in the English alphabet is called /waɪ/. They also pronounce those terms with / aɪ/ by analogy with "*analyze*"/ˈæn.ə.laɪ.z/, where y is pronounced /aɪ/. The participants even overgeneralized the /ai/ pronunciation to "*analysis*" which they pronounce /*æn.ə.laɪ.zɪz/ not /əˈnæ.lə.sɪs/ even though it is a noun and the pronunciation of y in the verb is different from that in the noun.

2) The letter name strategy is also applied in the pronunciation of *i* as /aɪ/ in allicin /*ælaɪsɪn/, vertigo /*vɜːrtaɪgoʊ/, pica /*ˈpaɪkə/, amino acid /*əmainoʊ/, alpha lipoic acid /*laɪpoʊɪk/, and cervical /*sɜːrvaɪkəl/ although *-ical* is an adjective suffix as in *biological, physical* and *geological* and is pronounced /ɪkəl/.

3) "*Combination*" was pronounced with /aɪ/ instead of /i/ due to the influence of the letter name in the alphabet. It seems that the participants extended the pronunciation of the verb "*combine*" /ˈkɒmbaɪn/ which is pronounced with /aɪ/ to the noun "*combination*" /*kɒmbaɪneɪʃən/ as they do not know that vowels might change in quality or length when the part of speech of a word changes from verb to noun or noun to adjective (*photograph* /ˈfoʊtəgræf/, *photography* /fəˈtɑːgrəfi/, *photographic* /foʊtəˈgræfɪk/).

4) In *Alkali*, the participants did not apply the letter name strategy in pronunciation the vowel i. They pronounced it differently from previous terms in #1, 2, 3, above, where i was pronounced /aɪ/. Since *Alkali* القالي was originally borrowed into English from Arabic and it is still pronounced القالي in Arabic, the subjects pronounced it with a long ي/i:/ as it is pronounced in Arabic. This means that the participants transferred the pronunciation of *Alkali* from Arabic (L1) to English (L2) although in English it should be pronounced /æl.kə.laɪ/.

5) The participants pronounced the term *Braille*, which is originally French, as /braɪl/ not /breɪl/. The mispronunciation of the vowel is affected by the Arabic transliteration of Braille as برايل and its pronunciation in Arabic as /braɪl/ which contains /aɪ/. Here again, the participants are transferring the pronunciation of *Braille* from Arabic (L1) to English (L2).

6) The term *plantar fasciitis* consists of Latin *fascia* + Greek *-itis*. Here two vowels should be pronounced: the last vowel in the route *fascia* and the first vowel i in the suffix *-itis* which should result in (fas-ci-i-tis). Arab healthcare professionals reduced

the double vowels 'ii' to one and pronounced them as a single diphthong /*fæʃaɪtɪs/ instead of pronouncing them as a vowel + a diphthong /fæʃiˈaɪtɪs/. Here, the mispronounced vowel stems from phonological reduction, where Arab professionals simplify complex vowel sequences due to unfamiliarity with the pronunciation of final vowels in Latin terms. The sequence ii in Latin terms can be encountered in other Latin plural terms as *radii & genii* as well.

7) The terms *neuralgia, metatarsalgia, myalgia, arthralgia, cephalalgia* end with the suffix *-gia* /dʒə/ which means *pain*. However, Arab healthcare professionals in this study pronounce the suffix -gia orthographically in terms like *metatarsalgia* /*mɛtətɑːrˈsældʒiə/, *myalgia* /*maɪˈældʒiə/, *arthralgia* /*ɑːrˈθrældʒiə/, *cephalalgia* /*sɛfəˈlældʒiə/ with /*dʒia/ instead of /dʒə/. This reduction stems from orthographic influence. Here, the subjects are transferring the Arabic grapheme-phoneme correspondence rule where every letter in a word is pronounced. They articulated the vowel sequence. In English phonology, the -ia at the end tends to be reduced in connected speech, especially in multisyllabic words. So -ia becomes a weak syllable, typically pronounced /ə/.

8) Although terms like *sterile, febrile* and *fragile* are pronounced with /aɪl/ in British English and /əl/ in American English, Arab healthcare professionals tended to pronounce words ending in -ile with /aɪl/ as /ˈfɛbraɪl/, and /ˈfrædʒaɪl/. Here the subjects are overgeneralizing the /aɪl/ variant as these terms are analogous to *combine* /kəmˈbaɪn/, *fine* /faɪn/ & *lime* /laɪm/. The subjects assume that words ending in *-ile* should follow the pronunciation of words with a similar spelling as *smile, file, fine, dime, line, combine, mine* and so on.

9) In terms ending in "-in", "-en", "-il", "-im" as *Aspirin, Melanin, Melatoni , Insulin, Amoxicillin, Hemoglobin, Penicillin, Serotonin*, *Nurofen, Eucerin, Bilirubin, Augmentin, erythromycin, Degasin, Ivarin, Colpermin, Duspatalin, Fucidin, Nurofen, Bilaxten, Hespredin*, diosmin, *Reparil, Perfectil, Amaryl, Dizinil Chlorophil, Diaoptim,* Arab healthcare professionals tend to favor the long vowel /iː/ in the final syllable becoming /iːn, iːl, iːm/, resulting in *Aspirin* /*æspəriːn/ *Melanin* /*mɛlənɪːn/, *Melatonin* /*mɛləˈtoʊnɪːn/, *Insulin* /*ɪnsəliːn/, *Nurofen* /*njʊrəfiːn/ (UK) or /*nʊrəfiːn/ (US), *Bilaxten* /*bɪlækstlːn/, *Reparil* /*rɛpərɪːl/, *Perfectil* /*pərˈfɛktɪːl/, *Amaryl* /*æmərɪl:/, *Dizinil* /*dɪzənɪːl/, *Chlorophyll* /*klɔːrəfɪːl/, *Diaoptim* /*daɪəˈɒptɪːm/ or /*diːəˈɑːptɪːm/. Here, there is interference from other English terms in which the vowel in the final syllable is pronounced /iː/ as in *Caffeine /kæfɪːn/ & Protein /ˈproʊtiːn/.* Arab healthcare professionals are overgeneralizing the long vowel pattern in other scientific terms ending in the long vowel *-ine*, as in *Dopamine* /ˈdoʊpəˌmiːn/, *histamine* /ˈhɪstəmiːn/ & *thiazine* /ˈθaɪəziːn/. The participants are probably assuming that *melanin* and *melatonin* and others should follow the same rule, even though they are spelled with "*-in*" not "*-ine*". In addition, pronouncing such terms with a long /iː/ in the final syllable may be due to orthographic influence from Arabic. In Arabic, these terms are often transliterated with a long ي/iː/ as in ميلاتونين انسولين اوجمنتين ديغاسين دسبتالين بيلاكستين ريباريل بيرفكتيل اماريل ديزينيل ديأوبتيم كلوروفيل and so on. In avoiding the lax vowel /ɪ/ (short *i* in English) at the end of these terms and lengthening the vowel, Arab speakers are also transferring the Arabic phonological system to English terms. They are mimicking Arabic plural nouns that end in /iː/ as *mu'minīn* مؤمنين, *muslimīn* مسلمين, reinforcing the tendency to lengthen the vowel in the final sullable. The influence of Arabic phonology is clear as such words are trisyllabic requiring a final long vowel in the final syllable, being the stressed syllable.

10) As for *Nivea,* Arab healthcare professionals pronounce it with a long vowel /*nɪːviə/ in the initial syllable instead of a short vowel /ˈnɪviə/ as in English. In the flow of Arabic speech, Arabic speakers apply the Arabic phonological rules to *Nivea* in order to maintain phonotactic harmony. They pronounce it with a long vowel by analogy to آسيا*Asia* /ʔaːsiə/ and Nadia نادية /naːdiə/. In addition, stress assignment in Arabic is largely predictable, falling on the penultimate syllable if it is heavy (closed or containing a long vowel), otherwise on the antepenultimate. Since the first syllable in */niviə/* is open and light, Arabic speakers redistribute the stress to equalize prominence across syllables which leads to a long initial syllable. So instead of pronouncing the word *Nivea* with a reduced /ɪ/ */ˈnɪviə/* as in English, they tense and lengthen the vowel to /iː/ and maintain long vowels in both syllables /*nɪːviə/. Pronouncing *Nivea* with long vowels is also orthographically influenced by the Arabic transliteration of *Nivia* نيفيا with the long vowel ي.

11) Similarly, vowel lengthening occurs in *Relaxon, Parafon, Pharmaton, Avalon, Pantozol* where the vowel in the final syllable *-on* and *-ol* changes from short /ɒ/ or /ə/ to long /ɔː/. This vowel lengthening can be attributed to phonological interference, orthographic influence, and syllable-timing differences between Arabic and English. Arabic does not have centralized vowels like /ə/ or reduced short lax vowels like /ɒ/, /ʌ/ or /əʊ/ in non-final unstressed syllables. So Arabic speakers often substitute unfamiliar lax vowels with more familiar tense vowels or diphthongs, especially /oː/. Secondly, English is a stress-timed language, which allows reduction of vowels in unstressed syllables as in the case of these medical terms where it falls on the second syllable. By contrast, Arabic is more syllable timed, as a result Arabic speakers often avoid vowel reduction in the final syllable of a trisyllabic words, leading to the lengthening of vowels in these terms /*pærəfoːn/. Thirdly, the final syllables *-on* and *-ol* visually look like *phone, tone, control, goal*. By analogy, Arabic speakers pronounce *Relaxon, Parafon, Pharmaton, Avalon, Pantozol* with a long vowel. In the flow of Arabic speech, pronouncing these terms with a short vowel would sound

cacophonous. The pronunciation of the vowel is overcorrected so that pronouncing the terms with /oː/ maintains phonotactic harmony. Moreover, in Arabic, final syllables often bear more phonological weight than in English. This encourages Arabic speakers to resist English vowel reduction and to lengthen the vowel in the final syllable to emphasize it and make it feel that it is phonologically acceptable. Interestingly, the vowel *-on* in *silicon* سيليكونis not lengthened as it is in *Relaxon, Parafon, Pharmaton, Avalon, Pantozol*. It is pronounced with /kən/ as in English rather than /oː/. It seems that Arabic speakers are more familiar with the English pronunciation with a short vowel as this term is commonly used in daily Arabic speech, so they pronounce it with a short vowel. Arabic speakers adapt both *Relaxon, Parafon, Pharmaton, Avalon, Pantozol* and *silicon* to native Arabic rhythmic templates.

12) The eu in *Euthyrox* and *Eucarbon* is pronounced /ʊ/ not /yʊ/ due to phonological substitution and simplification driven by both phonotactic constraints and orthographic misinterpretation. In words like *Euthyrox* /ˈjuːθɪrɒks/ and *Eucarbon* /ˈjuːkɑːbən/, the English initial glide-vowel sequence /juː/ or /jʊ/ is absent in Arabic phonology. They pronounce it orthographically as it is transliterated اوكاربونin Arabic. Moreover, the initial *eu-* is often perceived as /ʊ/ or /oː/ because Arabic speakers are accustomed to reading "eu" as /ʊ/ in words like *Europe* اوروبا. Arabic speakers tend to simplify complex onsets and preserve full vowels. On the contrary, in terms like *Neuroton, Neurobion, Neurological* that contain *eu* & *Tuberculosis* containing *u* in the initial syllable were pronounced as /ju/ or /jʊ/ instead of /ʊ/ or /u/. This is probably due to u letter-name interference because these terms are transliterated نيوروبيون نيوروتونin Arabic, and the initial syllable is a closed syllable, whereas in *Euthyrox* and *Eucarbon*, the initial syllable is an open one.

13) Unlike terms with the vowel u in *Humalog* is pronounced /Hi-ma-log/ due to phonotactic anchoring, orthographic cues, and lexical familiarity. To Arabic speakers, *Humalog* resists /j/ insertion because the initial /h/ provides a clear syllable onset, so there's no phonological "gap" that invites a glide. In contrast, *Neuroton* or *Tuberculosis* begin with vowel-like sequences (*neu-*, *tu-*) that feel unstable to Arabic speakers, prompting them to insert a /j/ for syllabic support. The spelling "hu-" does not resemble "eu-" or "neu-", which Arabic speakers often associate with the English letter name u> /juː/. Without that visual cue, there is no pressure to insert a glide. *Humalog* looks and feels like a CVCV structure.

Although *Humalog* is similar to *human* and *humanity,* it is not pronounced with */hjuː/*. *Human* and *humanity* are high-frequency academic words, often taught early and heard frequently in English instruction. Arabic speakers are exposed to the /hjuː/ pronunciation repeatedly. By contrast, *Humalog*, is a specialized medical brand name that is less likely heard in native English contexts, so Arabic speakers rely more on spelling-based approximation. *Human* is often transliterated as "هيومان" but *Humalog* is transliterated as "هيمالوج", with no glide marker like in نيو or هيُو. The transliteration "هيمالوج" for *Humalog* shows phonological accommodation and orthographic intuition in Arabic. It reflects spelling-based approximation, not strict phonemic mapping. The long vowel /iː/ is added to stabilize the onset and for clarity and familiarity purposes. This makes "هيما" a natural, pronounceable sequence. Moreover, Arabic packaging often favors euphonic, smooth-sounding transliterations to avoid ambiguity, make it easy to read aloud and to preserve brand identity. هيما" is smoother and more intuitive than /huma/ or /hjuma/, especially for patients unfamiliar with English phonology.

14) Other mispronounced vowels are the expression *wear & tear,* where they are pronounced by analogy to common words spelled with ea as *clean, read*, and *lead*, *team, teach, seat, meat* and so on. This mispronunciation of the vowel digraph as /wiːr ənd tiːr/ stems from a combination of orthographic misinterpretation, vowel reanalysis, and unfamiliarity, especially if the words are encountered in writing more than heard in speech. The vowel digraph "ea" is more commonly pronounced /iː/ in high frequency words as *clean*, *tea*, *mean*, *team*. "*Wear* and *Tear*" is often read literally, not as a fixed idiom. Without audio input or idiomatic awareness, Arabic speakers re-map *wear* and *tear* to the ea /iː/ vowel patterns. The participants may not be familiar with diphthongs like /eə/, and with idiomatic recognition, hence they prefer simpler, more stable vowels.

15) Arabic speakers pronounce *diet* as /*daɪt/ instead of the standard English pronunciation /ˈdaɪ.ət/ or /ˈdaɪ.ɪt/. There seems to be a deep interplay between orthography, phonology, and L1 transfer. Arab healthcare professionals seem to reduce the triphthong in /ˈdaɪ.ət/ or /ˈdaɪ.ɪt/ to a diphthong /*daɪt/ as Arabic does not have triphthongs (combination of three vowel sounds blended together smoothly). This means that they are reducing English triphthongs (combination of three vowels) to a diphthong (combination of two vowels). The pronunciation is affected by the transcription of *diet* in Arabic as دايت. The spelling *diet* contains "ie", which the subjects might interpret as a vowel digraph, similar to *skies, pies, tied, lied* , which are all monosyllabic words pronounced with /aɪ/. This creates the illusion that *diet* is just another CVC monosyllabic word.

16) Arab healthcare professionals in this study shortened the vowels in biomedical terms as *Galvus* /ˈgælvəs/, *Omega* /oʊˈmeɪgə/, *Mobic* /ˈmoʊbɪk/ based on phonological analogical mapping where they subconsciously match unfamiliar English terms to familiar Arabic prosodic frames based on syllable structure and stress. Arabic speakers subconsciously are matching unfamiliar terms with familiar native words. When they pronounce *Galvus* with short vowels they are mimicking

Arabic مكتب/maktab/ *desk*. In pronouncing *Omega* with short vowels, they are mimicking كُتِيبَ/kutaiba/ *written* & سُرِقَ /suriqa/ *stolen*. In pronouncing *Mobic* with a short vowel, they are mimicking إلك/?ilik/. These terms have a trochaic rhythm with a stressed syllable followed by unstressed, and with quick vowel drop-offs. The parallelism in intonation and compression encourages Arabic speakers to reinterpret *Mobic* with a shortened /o/ and clipped final syllable.

17) Participants in this study tended to pronounce the vowel in the final syllable of words like "*Rapidus,*" "*Centrum,*" "*Maximum,*" "*Minimum,*" "*Memory,*" and "*Serum*" with an /ʊ/ sound (as in "put") rather than a /ə/ sound (schwa) due to Arabic phonotactics influence. Arabic does not have unstressed centralized vowels like schwa /ə/, instead, every vowel is usually fully realized, often as /a/, /i/, or /u/ (whether short or long). Since /ʊ/ is closer to the Arabic /u/ than a reduced schwa, it becomes the go-to substitution. The Arabic short vowel "ḍamma" (ضمّة) or /u/ is often the closest acoustic approximation to the English schwa taking orthography into consideration, especially when the schwa is in a syllable that might be perceived as somewhat "rounded" or "back" by an Arabic speaker. It also seems that the subjects are mimicking the Arabic clitic pronoun *-um* that is typically attached to the end of nouns, verbs, adjectives and even prepositions as لهم/lahum/ (for them); منكم/minkim/ (from you), لكم/lakum/ (for you), كتابكم/kitabukum/ (your book), درستم/darastum/ (you studied) and so on.

As for *serum*, Arabic speakers pronounce *it* /*siː.roːm/ instead of /ˈsɪə.rəm/, with a long vowel in the final syllable, even longer than *um in* "*Centrum,*" "*maximum,*" "*minimum",* which seems to be influenced by a convergence of phonological gaps, orthographic triggers, and analogy. As in *Centrum,*" "*maximum,*" "*minimum"*, Arabic has no central reduced vowel /ə/. So the unstressed /əm/ is often replaced by the more tense, and full vowel /oː/ because it feels "complete" and aligns with Arabic vowel patterns. Syrian healthcare professionals, in particular, tend to pronounce *serum* as /*siː.roːm/, probably because this pronunciation is rooted in their French-influenced linguistic background. In French, *sérum* is pronounced as /se.ʁɔm/ or more phonetically close to /se.ʁœm/, with a full, rounded vowel at the end, not a reduced schwa as in English /ˈsɪə.rəm/. Arabic speakers familiar with French may associate the spelling and meaning directly with the French pronunciation and override the English reduction pattern.

Regarding the term *memory*, Arabic speakers often prefer full vowels over weak ones. So *memory* would is pronounced as /*memʊri/ to maintain vowel strength.

4. Discussion

Findings of the current study are partially consistent with findings of some prior studies which described vowel, consonant, consonant clusters, stress errors and others. For example, Albaaly (2022) noted errors in vowel reductions (/ə/ > /æ/) in consonant clusters in Egyptian medical educators' English. They mispronounce *patella* /pəˈtɛlə/ > /pæˈtella/). Arab medical students in India inserted vowels in consonant clusters as in *sclerosis* > /sɪklɪˈroʊsɪs/and made stress shifts (Khan & Salam, 2019). Hamar (2024) found L1 interference in Slovak students' pronunciation that includes /θ/ > /t/ and /l/-/r/ substitutions as in *therapy* > /ˈtɛrəpi/ (th-alveolarization). Japanese students made errors in vowel length /oʊ/ > /ɒ/ and liquid consonant /l/-/r/ as in *allergy* > /ˈærədʒi/ (Kawashima (2018). Indonesian students made diphthong reductions and silent-letter errors (/psaɪ-/ /saɪ-/) in *psychiatry* /psɪˈkaɪətri/, and spelling-induced errors in *syringe* /səˈrɪndʒ/ > /ˈsaɪrɪndʒ/ which is mispronounced according to spelling (Maharani et al., 2020, Ulinuha et al., 2024). Serbian students' substituted consonant /v/ > /w/ and misplaced stress in *venous* /ˈwɛnəs/ (Marošan & Marković, 2010). Iranian students confused /v/-/w/ and made vowel-length errors in *ventricle* > /ˈwɛntrɪkəl/ (Sanaee et al., 2013). Khan & Salam (2019) focused on phonological interference from Arabic by Arab medical students and found that the most frequent errors were vowel elongation, incorrect stress placement, and confusion between voiced and voiceless consonants.

The vowel pronunciation errors in biomedical terminology are partially similar to errors found in pronouncing foreign Proper Nouns by educated Arabis and student interpreters in Al-Jarf (2022b) and Al-Jarf (2022c). These two studies reported vowel mispronunciations as in *Google*, *Uber*, *London*; syllable reversal and vowel epenthesis in consonant clusters (*Beligrade*, *Serbrenica, Zelinsky*, *SNAS,*) and orthographic pronunciation, i.e., reading words as spelled (e.g., *Nike*, *Huawei*); mishearing names like *Davos*, *Missouri*, *Scandinavia*; producing rhyming but incorrect forms (*Dabos instead of Davos*; *lizouri instead of Missouri*); substitutions with phonetically similar words but semantically unrelated words (e.g., *Volcanoes* for *Balkans*); omitting syllables or segments (*Buja* for *Abuja*); phoneme substitution (*dracola* for *Dracula*); overgeneralizing Arabic pronunciation (*Ardoghan*, *Athina*) and others.

The vowel pronunciation errors made by healthcare professionals in the current study showed three main causes: (i) Orthographic Influence where the participants tended to apply names of letters in the alphabet and use it as a pronunciation rules, e.g., *cervical* > */sir-vay-kul/* due to "i" being named */ay/*. (ii) Overgeneralization from related words. i in *combination* is

pronounced as the original verb *combine* with an /aɪ/. (iii) Overgeneralization of familiar patterns to new biomedical terms as in pronouncing *amylase* with /ai/ due to analogy with *analyze*.

As in the current study, numerous studies classified learners' errors into interlingual (those that stem from the learner's native language (L1) interference); intralingual errors arising from within the target language (L2), such as overgeneralization or incomplete rule application; and developmental categories that reflect stages in language acquisition, often shared by both L1 and L2 learners. Hamar (2024) emphasized that pronunciation errors in medical terms are not random but systematic, and that they are shaped by the learners' linguistic background and the multilingual environment of medical education. Hamar (2024) explicitly attributed the sources and causes of pronunciation errors among Slovak medical and dental students to interference from Slovak (L1), i.e., differences in phonetic inventory and stress patterns between Slovak and English which lead to predictable mispronunciations, interference from Latin pronunciation norms which complicates English term articulation since students also study Latin medical terminology, and from English itself as inconsistent English spelling-to-sound correspondences and unfamiliar phonotactics contribute to intralingual confusion. Vowel reduction avoidance and pronouncing all syllables fully, simplification or omission of consonant clusters, and voicing/devoicing errors are all due to L1 transfer and overgeneralization of English pronunciation rules (intralingual errors).

Moreover, problems that healthcare professionals have in pronouncing vowels in biomedical terms are probably due to insufficient knowledge of grapheme-phoneme correspondence. Those pronunciation errors are similar to misspelled vowels by freshman EFL students in general words which revealed weaknesses like confusing short and long vowels (*ship* vs. *sheep*); substituting one short vowel for another (e.g., *bet* > **bit*); misusing schwa and unstressed vowels, especially in suffixes and multisyllabic words; deleting medial or final vowels, particularly in unstressed syllables (*separate* > **seprate*); omitting silent vowels (*guide* > **gude*); inserting unnecessary vowels in consonant clusters (*splendid* > **sepilendid*); adding vowels after long vowels due to overgeneralization (*cake* > **caake*); and confusing vowel combinations like *ea*, *ie*, *ou*, *oo* (*receive* > **receeve*); misinterpreting digraphs as separate sounds. These vowel errors are probably due to confusing vowel spelling patterns and digraphs, auditory discrimination deficits, i.e., inability to hear or differentiate vowel phonemes accurately, phonological interference from Arabic, i.e., influence of Arabic vowel system leading to misperception or mis-production of English vowels, and difficulty distinguishing lax and tense vowels not present in Arabic, overreliance on phonetic spelling, analogies, or L1 transfer; visual memory issues, decoding and listening comprehension weaknesses which showed strong correlation with vowel spelling errors, or lack of exposure to native pronunciation, i.e., limited familiarity with vowel variation in natural speech (Al-Jarf, 2019; Al-Jarf, 2010b; Al-Jarf, 2009; Al-Jarf, 2008b; Al-Jarf, 2008c; Al-Jarf, 2007; Al-Jarf, 2005a; Al-Jarf, 2005b; Al-Jarf, 1999).

5. **Recommendations**

Improving vowel pronunciation accuracy in biomedical terms requires pronunciation training for both students and faculty and professionals. For improving students' pronunciation of English biomedical terms, prior studies recommended several strategies such as integrating pronunciation and phonetics training into medical education curricula and medical English textbooks; language training, phonology courses, and practice and interaction with native speakers to improve fluency and internalize correct pronunciations of biomedical terminology; incorporating minimal-pair exercises, multisyllabic word drills, systematic phonetic drills and interactive pronunciation exercises to enhance students' fluency in medical English; contextual pronunciation drills (e.g., hospital supply lists); collaboration with native-English pharmacists; listening to native speakers for reinforcement; assigning students short role-play exercises mimicking doctor-patient interactions; shadowing exercises with native speakers; clinical communication labs focusing on high-frequency terms; and applying the medical oral language proficiency assessment (MOLPA) for students and residents in the healthcare field before graduation (Meymeh & Khadembashi, 2015; Khan & Salam, 2019; Hamar, 2024; Ulinuha et al., 2024; Khan & Salam, 2019; Albaaly, 2022; diamond, et al. (2023).

In addition, introducing a pronunciation table helps students decode medical terms more easily. Since, students often mispronounce vowels and consonant clusters, particularly in Latin-derived medical vocabulary, categorizing terms based on phonetic structure in the pronunciation table provides a systematic approach to improving medical English fluency. Phonetic transcription and visual guides are effective tools for pronunciation learning (Kawashima, 2018).

Since the vowel pronunciation errors in biomedical terms are linked to specific vowels in certain environments, a lexical approach to biomedical terminology instruction where pronunciation is taught as part of the medical courses can be effective. In teaching specialized terminology, Al-Jarf (2022a), Al-Jarf (2023b), Al-Jarf (2019); Al-Jarf (2008a), and Al-Jarf (2006) recommended connecting the printed form of the terms with their pronunciation vis connecting the phonemes with their graphemes; terms with same vowel digraphs but different pronunciation (*heart, heard, clean, clear);* terms with different vowel digraphs but same pronunciation (*deceive, lead, keep);* homophones (*sight, site, cite);* homographs (*bass & bass, read & read);* pronunciation of foreign terms with Latin plurals (*radii, vertebrae, bacterium, cocci)* and others.

In addition, a variety of technologies and visual aids can be used to improve medical students' pronunciation as color-coded stress markers) for EFL medical learners and repetition-based practice (Kawashima, 2018); audio glossaries with slow-motion articulation (Maharani, 2020); interactive pronunciation software (Marošan & Marković, 2010); custom Automatic Speech Recognition (ASR) models for non-native accents (Mani et al., 2020); and pronunciation flashcards or posters in break rooms with common medical terms.

Moreover, ample exposure to authentic spoken English and authentic pronunciation of native English healthcare professionals through the utilization of text-to-speech software can enhance the decoding skills and pronunciation accuracy of medical terminology. Listening to medical mobile audiobook apps, medical podcasts, medical animations and YouTube videos for self-regulated pronunciation practice, medical TED Talks for authentic listening and pronunciation, and MP4 listening and pronunciation lessons for medical students are also helpful. The students can practice listening to English native speaking health professionals and shadowing their pronunciation in a digital multimedia language lab. Healthcare instructors can use mind-mapping software to show phoneme-grapheme correspondences in biomedical terms, Greek and Latin roots, prefixes and suffixes comprising medical terms, and singular and plural forms of Latin medical terms (Al-Jarf, 2023a; Al-Jarf, 2022d; Al-Jarf, 2022e; Al-Jarf, 2021a; Al-Jarf, 2021b; Al-Jarf, 2021c; Al-Jarf, 2021d; Al-Jarf, 2020; Al-Jarf, 2017); Al-Jarf, 2014; Al-Jarf, 2012; Al-Jarf, 2011a; Al-Jarf, 2011b; Al-Jarf, 2010a).

Since students in the healthcare fields imitate their instructors' pronunciation of biomedical terms, improving vowel pronunciation in biomedical terms while health professionals and faculty are actively working requires practical, real-time strategies integrated into their daily routines such as continuous phonetic training for medical staff to prevent misunderstandings that could impact patient safety (Albaaly, 2022; Horani, 1995); teaching correct vowel shifts to healthcare professionals; listening to native speakers for reinforcement; implementing short, focused workshops on common mispronunciations in biomedical terminology; encouraging peer corrections in daily conversations to build awareness; providing voice-enabled medical mobile and online dictionaries for instant pronunciation checks; encouraging them to check pronunciation by AI tools such as Google Translate; implementing AI-powered speech recognition to familiarize health professionals with correct pronunciation; using text-to-speech apps with verified pronunciation of medical terminology; shadowing senior healthcare professionals and native speakers' pronunciation; self-recording and playback to identify vowel mispronunciations; encouraging team discussions about mispronunciations that affect communication; reminding professionals that clear pronunciation reduces miscommunication with patients especially foreign ones; and developing simple pronunciation tip sheets for departments handling complex terminology.

Following some or all of these strategies ensures that Arabic-speaking healthcare students, faculty and professionals will avoid lifelong vowel pronunciation errors. Other types of pronunciation errors by healthcare students and professionals, such as geminating consonants in biomedical terms, are still open for further investigation in the future.

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