

RESEARCH ARTICLE

# Impact of the “DrugSpeak” programme on drug name pronunciation skills and perceptions in a pharmacy student cohort

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## Abstract

**Introduction:** Difficulties in pronouncing many drug names can lead to medication errors in pharmacy practice. A pilot study called DrugSpeak was devised to provide educational scaffolding to enable students to pronounce drug names correctly. **Method:** Student participants (n=26) accessed online videos on phonetics and audio files of drug names, then undertook a workshop that provided them with basic phonetics training to assist them in pronouncing drug names correctly. Surveys and audio recordings of student pronunciations of drug names were conducted before and after intervention with DrugSpeak. **Results:** Significant increases ( $p < 0.01$ ) in student drug pronunciation and accuracy were observed following DrugSpeak. Students reported reductions in anxiety and enhancements in their confidence levels relevant to drug pronunciation. **Conclusion:** The DrugSpeak education package yielded promising outcomes in the improvement of student drug pronunciation skills and in providing students with the confidence to tackle drug names unfamiliar to them.

## Introduction

Medication errors lead to preventable medication-related adverse drug reactions, hospitalisations, and deaths, with an annual global cost of USD 42 billion (World Health Organization [WHO], 2017). Numerous contributing factors lead to medication errors. Up to 25% of all errors arise when patients receive the incorrect drug when another drug was intended for the treatment, also known as “wrong drug” errors (Abdellatif *et al.*, 2007; Emmerton & Rizk, 2012). This issue is commonly associated with pairs of drugs that possess confusingly similar names, both orthographically (written) and phonetically (spoken), and are known as look-alike sound-alike (LASA) drugs (Davis, Cohen & Teplitsky, 1992; Phatak *et al.*, 2005; James *et al.*, 2009). Such medication errors present a severe threat to patient healthcare and can lead to malpractice claims against pharmacists and other healthcare professionals (Cohen, 1995). Exacerbating the problem are the difficulties experienced by both students and clinicians alike in

recalling drug names (Lambert, Change & Lin, 2001; Lambert, Chang & Gupta, 2003; Schroeder *et al.*, 2017), especially since many of the names are long and contain multiple syllables. While numerous attempts have been made to address the difficulties associated with incorrect spoken medication errors, they have been met with varied success and without a suitable remedy to adequately address the problem (Bryan *et al.*, 2021).

The mispronunciation of drugs in the healthcare profession, particularly involving LASA drugs, presents another substantial source of medication error (Lambert *et al.*, 2010). Fluency in drug pronunciation is an essential graduate attribute for health professional students, and yet methods that improve student drug pronunciation proficiencies have received little attention. It is concerning that such a critical form of communication has been largely overlooked as a source of such errors (Aronson, 2009). Correct, uniform drug pronunciations are not only essential in the healthcare sector to prevent the appearance of a lack of professionalism (Frank,

2018), but it is an essential mechanism by which the human transcriber delivers information on complex medications (Palanica *et al.*, 2019). Indeed, verbal communication remains one of the highest-ranking employability skills in the STEM (Science, Technology, Engineering and Mathematics) industry (McGunagle & Zizka, 2020). Additional need for intervention in this regard arose from previous observations that many students were unable to correctly pronounce many of the hundreds of drug names at the conclusion of their program in their final year of study (Cheesman *et al.*, 2020), which leads to reduced graduate outcomes and poorer performances in job interviews. For example, a report more than two decades ago showed that students entering tertiary education are poorly equipped with requisite literacy skills but were also graduating without language proficiency in these skillsets (Holder *et al.*, 1999; Palmer *et al.*, 2014; Palmer *et al.*, 2018) and there is little evidence since to suggest this has been rectified.

To assist in drug pronunciations, the phonetic spelling of the drug name can help, but this requires proficiency in translating the drug name into correctly spoken words (Frank, 2018). Although pharmaceutical companies have included drug pronunciation in their medication information sheets, most consumers are neither versed in using the International Phonetics Alphabet to construct accurate pronunciations. Further, online sources of drug pronunciations are sparse and often utilise computer-generated speech that is pronounced inconsistently between sources (Patterson, 2018). While pronunciation “training” has been utilised with some success in the past to improve English word pronunciations in foreign language classes (Khaghaninejad & Maleki, 2015; Brekelmans, 2017), similar approaches have not been used for the pronunciation of generic drug names. Indeed, research into word pronunciation itself has been largely overlooked; hence, the pedagogy in this area remains uninformed due to the lack of connection between research and practice (Levis, 2016).

To redress this gap, the present study sought to improve the drug pronunciation skills of second-year pharmacy students through collaborative work involving pharmacists and speech pathologists using the design, implementation, and evaluation of a drug pronunciation proficiency education package named “DrugSpeak”. DrugSpeak consists of a series of educational activities designed to provide students with background phonetic and linguistic knowledge to enable them with skills to decipher and pronounce drug names in a universally acceptable manner. This program ultimately seeks to mitigate the risks of medication errors that could occur when the graduates begin employment in the healthcare sector.

## Methods

### Aim

The present study had two aims. The first objective was to gain an understanding of student perceptions of the importance of drug pronunciation in their studies and career. The second objective was to investigate whether a targeted intervention with the DrugSpeak program resulted in improvements in students’ ability to pronounce drug names more accurately and fluently.

### Participants

The study was conducted among all the students (n=56) enrolled in the Integrated Pharmacotherapeutics 1 (2009PHM) course within their Bachelor of Pharmacy degree programme at Griffith University (Gold Coast, Australia), and participation in the scholarly review process was voluntary. Of these, 26 students participated fully in the study and comprised 18 female and 8 male students. Data from the remaining 26 students were excluded as these students did not participate in one or more of the data collection points (e.g., surveys, recordings), which would have prevented comparisons from being made between collection points for these students. The average age of the cohort was 22 years old, while the age distribution was from 19 to 46 years of age. More than 85% of students reported English as their native language, with the remaining comprising Korean, Hindi, Telugu, Cantonese, Vietnamese, and Arabic. The 2009PHM course was chosen since it was the first course in their degree programme, where knowledge of specific drugs is required and assessed. Students were informed of the DrugSpeak programme and its design and purpose and that it was being used to help students establish a solid foundation in drug pronunciation proficiency.

### Surveys

A survey was conducted prior to any exposure to the DrugSpeak programme intervention and repeated immediately after the DrugSpeak workshops. Student perceptions about drug names, their pronunciation learning strategies, and the perceived importance of fluent drug name pronunciation were collected through six questions in this first survey. Students indicated their response on a 5-point agreement Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree). To ensure participant confidentiality, students created a 6-digit code for their identification during the study. Participant codes for the pre-workshop survey were further deidentified with a randomly generated 4-digit code for subsequent analysis to ensure researchers did not have access to student names that were connected to the original 6-

digit code until after data analysis. This de-identification approach was used for all student surveys and recordings in the study. Towards the end of the course (and thus at the end of the DrugSpeak programme intervention), a second survey was conducted consisting of the same questions as the first survey. Finally, a third survey was conducted, including eight questions related to student experiences with the DrugSpeak programme.

### **The DrugSpeak programme**

The DrugSpeak programme was underpinned by literature on linguistics specific to word pronunciation, as well as new word learning, neurolinguistics, and adult learning approaches. As such, the programme primarily employed a bottom-up, skills-based teaching approach, but also taught complementary top-down pattern recognition strategies. Specifically, the programme focused on teaching basic structural concepts and rules of word pronunciation, building up from phonemes (sounds) to syllables to words. At the word level, syllable identification, stress placement, intonation, melodic contours (prosody or suprasegmentals), and stem recognition were addressed (Underhill, 2005; Kelly, 2001; Levis, 2016). The DrugSpeak programme was delivered in the following order:

**Part 1. Pre-workshop:** students were given access to three pre-recorded videos of approximately 10 minutes duration each on their course website. These videos covered the basics of word pronunciation and the key fundamentals of spoken language and were provided to students on the first day of the course.

**Part 2. Workshops:** face-to-face active learning workshop (three hours) delivered during tutorial classes. These “training” workshops applied the concepts introduced in the videos during Part 1, providing further instruction and application of pronunciation skills and strategies. During these workshops, students participated in small group activities to discuss the structure, phonetics, and suprasegmentals relevant to drug names, followed by verbal practice of 49 different drug names that had been selected for the intervention. Students were also provided with audio examples of each drug name (made available on the course website for the entire duration of the course). These audio examples allowed them to compare their pronunciation attempts with those spoken by an expert and further practice their pronunciations. Students completed the verbal tasks in pairs within groups and a workshop booklet; they were supplied with additional drug names for private study and practice outside of class.

**Part 3. Post-workshop:** students continued to have access to recordings located on the learning management system. Drug name pronunciations were also reinforced in lectures and tutorials.

### **Audio recordings**

Audio recordings of drug name pronunciations were collected from willing participants under the observation of research assistants. Recordings were conducted in small private rooms to avoid interruptions and have minimal background noise. Two separate recordings were conducted for the cohort. A pre-programme before starting the DrugSpeak programme intervention and named the pre-recordings and a post-programme recording in the final week of the course following completion of DrugSpeak activities, which was named the post-recordings.

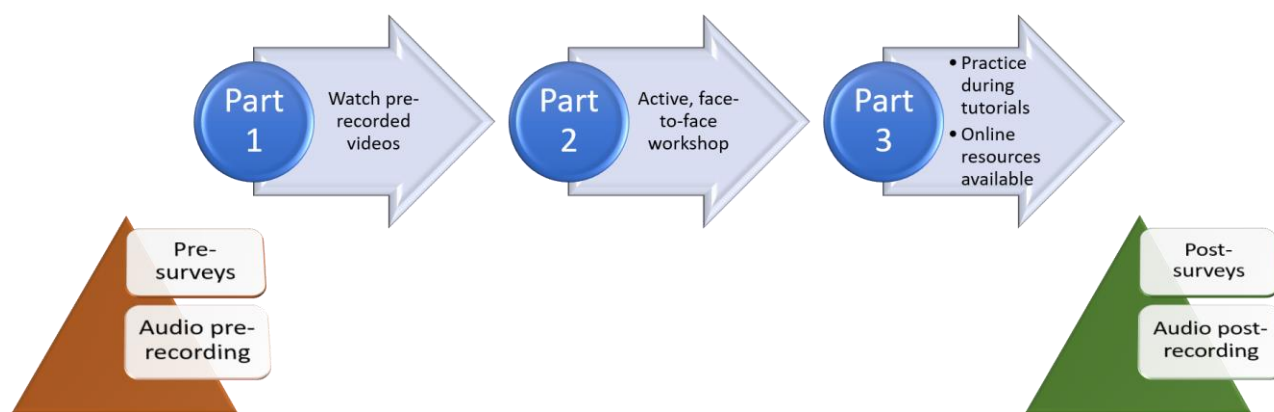
Audio recordings were captured using Olympus WS-852 Digital Voice Recorders. Students were asked to pronounce a series of 113 drug names divided into five familiarisation (control), 49 treated, 49 untreated, and 10 novel unexposed drug names. These names were displayed individually (one drug name per slide) at the centre of the computer screen on a PowerPoint presentation. Students were permitted to advance to the next slide when ready for the following drug name. An audible alert signalled the display of the next new drug name; it assisted with downstream data analysis where the times between the display of the word and the attempt(s) made by students to pronounce them could be measured.

The presentation began with five “control” drug names that included simple and well-recognised drug names such as “aspirin” and “paracetamol” to ensure the participant was comfortable and familiar with the procedure. The following 49 drug names included those studied during the DrugSpeak programme activities, workshops, and online materials. The drug names ranged from two syllables to seven syllables in length. These were followed by an additional 49 drug names that were different to those used in the DrugSpeak intervention but contained word structures that were deliberately matched (i.e., by number of syllables, length, and stress patterns) to the drug names used in the intervention. Using matched treated and untreated drug name sets in the pre-recordings and post-recordings helped determine whether the intervention was word-specific or if there were generalisation effects to untreated words from the strategies taught during the DrugSpeak programme. The matching of the Treatment and Untreated sets was carried out by a speech pathology academic and was derived from a list of common drug names provided by pharmacy academics. Towards the end of the recordings, ten

drugs that would be completely unfamiliar to students, such as drugs not yet released, were presented (i.e., the “New” drugs). These final drug names served as a further measure of the extent to which students could apply and generalise the pronunciation principles learned throughout the DrugSpeak programme to drug names that were highly likely to be unfamiliar to them. To summarise, the audio recordings consisted of 113 drug names that included 5 control drug names, 49 drug names used in DrugSpeak and the course, 49 drug names not used in DrugSpeak but contained word structures that were similarly matched to those used in

DrugSpeak, and 10 unfamiliar drug names (5 + 49 + 49 + 10 = 113).

The post-recordings were completed by students in Week 11, and these included the same drug names as in the pre-recordings in Week 1. Since there were approximately 11 weeks between pre-recordings and post-recordings, this time interval was considered sufficient to prevent student familiarity with the words shown in the first recording, which could confound the research. The complete timeline of the project is shown in Figure 1.



**Note:** Students completed surveys and audio recordings prior to watching pre-recorded videos on drug pronunciation (Part 1) and the DrugSpeak workshop (Part 2). Students could practice drug pronunciations during tutorials held during the course and given access to audio files containing drug pronunciations for all drugs studied during the course (Part 3). Finally, post-surveys and audio recordings were conducted towards the end of the course.

**Figure 1: Timeline of the DrugSpeak project**

### Data analysis

The pre-survey and post-survey responses to each question were counted and collected into groups based on response type, then displayed using Tableau Software (Beard & Aghassibake, 2021). All de-identified audio recordings were stored in one folder containing their 4-digit codes without any indication of being from the pre-recordings or the post-recordings to help eliminate bias that could arise since student attempts in the post-recordings may be perceived as more proficient. Analysis was performed with Audio Audition (2020) using a background noise reduction to remove baseline static, with accuracy and fluency being the key measures. Accuracy of pronunciation was determined according to phonetic sounds, syllables, and stress placement criteria and compared to the correct phonetic transcriptions according to the International Phonetic Alphabet (Cram, 2018). Exceptions were made for two different commonly used pronunciations, e.g., <ine> could be pronounced like the [ine] in “dine” or [een] in “green”. Pronunciation errors were recorded as phoneme errors (syllables pronounced

incorrectly) and stress errors (when stress was placed on the incorrect syllable). Pronunciation fluency was measured through the time taken (speed) to pronounce the word and was measured from the alert tone where drug names were displayed until the offset point in the speech sound wave. The time between the alert tone, rather than at the onset of speech, was considered relevant as it represented the time taken for the speaker to process the word; thus, it allowed for differences between simple or familiar drug names and those that were unfamiliar or more complex to be studied. As a further indicator of fluency, the number of student attempts to pronounce each drug name was also determined, even in cases where the entire word was not pronounced.

Once all parameters had been collected and data analysed, all de-identified audio files were matched by accessing a master document that revealed which files were pre-recordings and post-recordings. These could be identified by showing students’ personal 6-digital codes and the date of the recording, which allowed researchers to link pre-recordings and post-recordings

conducted with the same student. Of the 66 audio recordings obtained in the study, 34 were identified as pre-recordings and 32 as post-recordings. Matching the student codes showed that 26 student participants conducted both the pre-recordings and the post-recording, allowing for the assessment of improvements, if any, in student drug pronunciation skills following the intervention with the DrugSpeak programme. Students who did not participate in either of the recordings were excluded from further analysis.

### **Statistical analysis**

All statistical analyses were performed using IBM SPSS Statistics (Version 25, IBM Corp, Armonk, NY). A total of 2808 lines of paired data were collected across the 26 participants. The accuracy of pre-post paired responses was analysed using the nonparametric McNemar chi-square test with post-hoc analyses, in addition to Wilcoxon signed-rank tests. Despite non-normal distribution (i.e., positively skewing) across the response time data for speed, the large data set and the fact that ANOVA is robust in handling outliers (Tanaka, 1987) indicated parametric statistical analyses, including ANOVA and paired t-tests (2-tailed) for these data.

Two additional fine-grained statistical analyses were undertaken related to accuracy and speed. First, syllable-level analyses were conducted for accuracy and response time to account for the fact that words ranged in syllable length from 2-7 syllables, which, hypothetically, could influence accuracy and fluency. Specifically, only words that were correct both pre- and post-intervention were included in these speed analyses (N = 1404) to ensure further consistency. Prior analyses based on visual inspection confirmed that statistically, significantly slower response times occurred for incorrect responses. Second, pre-post comparisons were undertaken across the 49 Treated drug name word set presented throughout the DrugSpeak programme, the Untreated matched set, and the 10 New Name set for accuracy to investigate generalisation and word learning effects. Passed or skipped attempts were recorded as incorrect but presented as missing data for the time and number of attempts parameters. In instances of missing data, the values were replaced with the mean value of completed data sets for the question, in line with studies that have shown the substitution of missing data with total means was more accurate than data pairwise deletion (Tsiriktsis, 2005).

For comparisons in pre-post survey responses, due to the relatively small sample size and use of ordinal

matched-pair data, pre-post program confidence and perceptual data were analysed using nonparametric statistics, specifically Wilcoxon signed-ranks tests.

### **Ethics approval and consent to participate**

Student participation was voluntary and research data collection required informed, signed consent. Ethics approval was obtained from the Griffith University Human Research Ethics Committee (GU Ref No: #2018/238).

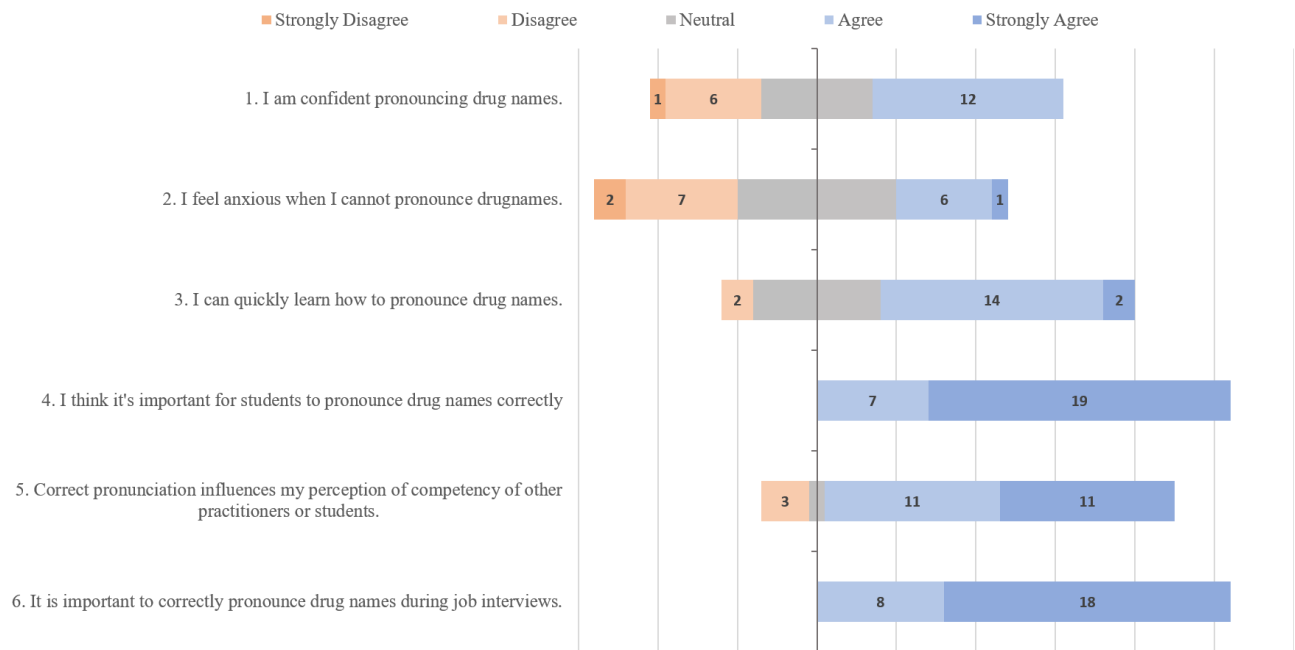
## **Results**

### **First survey (pre-survey)**

All 26 participants completed a pre-programme survey with six questions to establish their baseline perceptions and confidence in pronouncing drug names (Figure 2). There was no missing data. Almost half (46%) of these students were confident in pronouncing drug names, with the remainder disagreeing (26.9%) or neutral. The responses on confidence were generally concordant with student responses on anxiety, where 35% of students disagreed that drug pronunciation made them anxious, although 7 students agreed with that question, and 10 of the 26 students were neutral. Most students were either neutral or agreed that they could pronounce drug names quickly. Almost all students agreed with three questions, i.e. the importance of drug pronunciation, perceptions of student and health professional competency, and pronouncing drug names correctly during job interviews.

### **Second survey (post-survey)**

Following the DrugSpeak learning activity, 26 students completed a post-survey, which contained the same questions as the first survey. Only five missing responses were recorded across all questions. The results are shown in Figure 3. Students once again agreed that they are confident pronouncing drug names (69.2%), but half of the cohort reported feeling anxious when unable to pronounce drug names. Students overwhelmingly agreed to the remaining questions on their ability to quickly learn how to pronounce drug names (76.9%), the importance for students to correctly pronounce drug names (96.1%), perceptions that correct drug pronunciation is linked to the competency of other students or practitioners (65.4%), and the importance of correct drug name pronunciations during job interviews (92.3%).



**Note:** The total number of students was 26. A right skew (blue and dark blue) indicates positive agreement while a left skew (orange or dark orange) indicates disagreement. Neutral responses (grey) are shown spanning the central line. The size of each category is proportional to the percentages of responses.

**Figure 2: Pre-survey questions and student responses**



**Note:** The total number of students was 26. A right skew (blue and dark blue) indicates positive agreement while a left skew (orange or dark orange) indicates disagreement. Neutral responses (grey) are shown spanning the central line. The size of each category is proportional to the percentages of responses. \* indicates that there was one missing response, \*\* indicates that there were two missing responses.

**Figure 3: Post-survey questions and student responses**

**Comparison of pre- and post-survey responses**

The mean scores for each of the six questions asked in the pre- and post-surveys were subjected to a Wilcoxon signed-rank test, and the results are shown in Table I. Statistically significant increases in the post-survey

were observed for question 1 (confidence in pronouncing drug names) ( $Z = -2.54, p = 0.011$ ) and question 3 (confidence in learning how to pronounce drug names) ( $Z = -2.84, p = 0.005$ ) following DrugSpeak. No significant differences were found for the other questions.

**Table I: Comparison of pre-survey and post-surveys responses.**

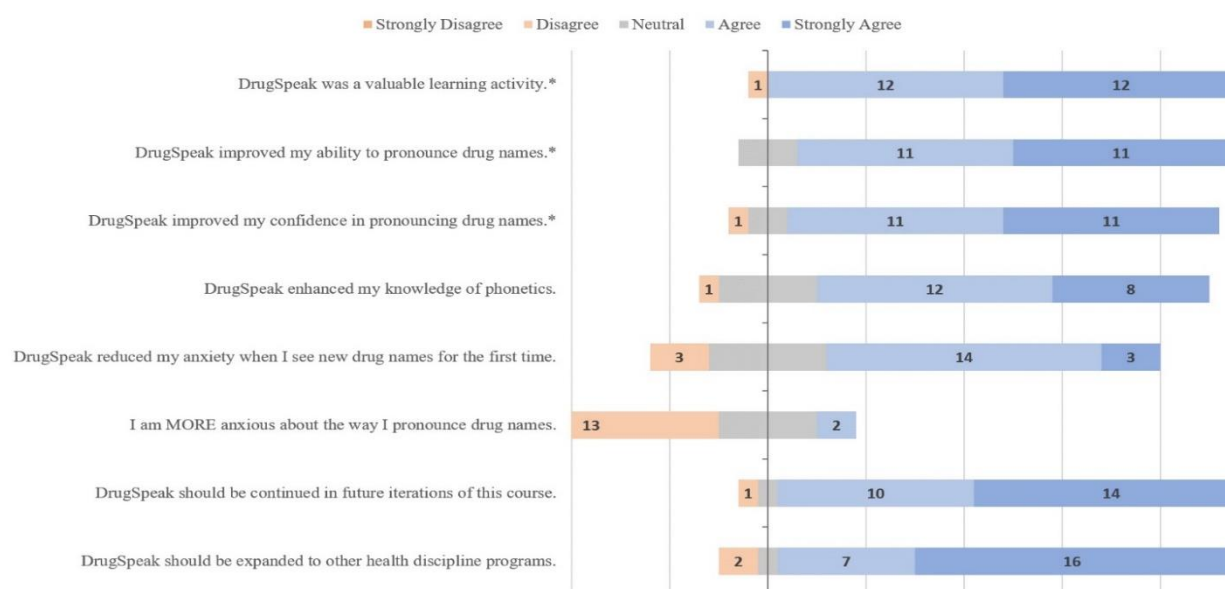
Question	Pre-survey score (mean ± SD)	Post-survey score (mean ± SD)	Difference	Z	df	p (2-tailed)
1	<b>3.27 ± 0.83</b>	<b>3.77 ± 0.82</b>	<b>0.5 ± 0.86</b>	<b>-2.54</b>	25	<b>0.011</b>
2	3.12 ± 0.86	3.38 ± 1.02	0.27 ± 1.08	-1.442	25	0.149
3	<b>3.62 ± 0.75</b>	<b>4.04 ± 0.66</b>	<b>0.42 ± 0.64</b>	<b>-2.84</b>	25	<b>0.005</b>
4	4.73 ± 0.45	4.8 ± 0.4	0.07 ± 0.4	-0.849	25	0.396
5	4.15 ± 0.97	4.25 ± 0.86	0.1 ± 1.07	-0.297	25	0.766
6	4.69 ± 0.47	4.64 ± 0.56	+0.05 ± 0.53	-0.452	25	0.651

**Note:** Questions where significant increases in rank mean of the responses (out of 5 using the Likert scale) were observed in the post-survey are indicated in bold. SD = standard deviation; Z = Z-value for a 95% confidence interval; df = degrees of freedom.

**Third survey (student feedback on DrugSpeak experience)**

An additional post-survey was conducted to collect general student feedback on the DrugSpeak learning activity. The results are shown in Figure 4. Almost all (92.3%) participants agreed or strongly agreed it was a valuable learning activity, with the majority of students agreeing that DrugSpeak improved their ability to pronounce drug names. Most participants agreed or strongly agreed that the programme improved their confidence in pronouncing drug names (84.6%),

enhanced their knowledge of phonetics (76.9%), and reduced their anxiety when encountering new names for the first time (65.3%). The anxiety data were complemented by the observation that most of the cohort (73%) disagreed with the statement that DrugSpeak increased their anxiety relevant to the pronunciation of unfamiliar drug names. Further to these positive outcomes, the overwhelming majority of students recommend DrugSpeak be used in future iterations of the 2009PHM course (92.3%) and that it should also be embedded within other health degree programs (88.5%).



**Note:** The total number of students was 26. A right skew (blue and dark blue) indicates positive agreement while a left skew (orange or dark orange) indicates disagreement. Neutral responses (grey) are shown spanning the central line. The size of each category is proportional to the percentages of responses. \* indicates that there was one missing response.

**Figure 4: Third survey data revealing general student feedback on the DrugSpeak learning activity**

### Student pronunciation performances in audio recordings

Analysis and comparison of the pre- and post-recording audio files following the DrugSpeak programme revealed that student drug name pronunciations were significantly more accurate ( $p = <0.001$ ) and fluent as

measured by being faster ( $p = <0.001$ ) and making fewer attempts ( $p = 0.002$ ) (Table II). The mean number of drug names correctly pronounced before DrugSpeak was 75.5 out of a total of 108 drug names (69.9%) and increased to 85.5 out of 108 drug names (79.2%) after DrugSpeak.

**Table II: Audio analysis of pre- and post-recordings and their comparison**

Pronunciation parameter	Pre-recording score (mean $\pm$ SD)	Post-recording score (mean $\pm$ SD)	Difference (mean $\pm$ SD)	$p$
Accuracy (%)	75.5 $\pm$ 14.7	85.5 $\pm$ 15.1	-12.0 $\pm$ 14.4	<0.001
Average time per word (seconds)	3.6 $\pm$ 2.9	2.77 $\pm$ 1.8	-1.1 $\pm$ 2.5	<0.001
Attempts per word	1.3 $\pm$ 0.7	1.2 $\pm$ 0.2	-0.1 $\pm$ 0.2	0.002

Note: SD = standard deviation

### Accuracy of matched Treated, Untreated, and New word sets

The audio recordings tested drug names that were studied during the DrugSpeak program (Treated drug set), drug names not included in the program (Untreated drug set), and unfamiliar names of drugs not yet released to the market (New drug set). Student drug pronunciations showed improvement in all three of these matched word sets following DrugSpeak. Specifically, the Treatment drug set showed an 18.8% increase, the Untreated drug set yielded an 18.2% increase, while the New drug set showed a 27.2% increase. Statistical analyses using the McNemar chi-square test revealed a significant proportional increase in accuracy for the Treated set ( $\chi^2 = 150.693$ ,  $p = <.001$ ) and Untreated set ( $\chi^2 = 79.314$ ,  $p = <.001$ ) but not for the New Word set ( $\chi^2 = .379$ ,  $p = .538$ ).

## Discussion

This work represents the first study of its kind in that it uses a drug pronunciation learning programme to directly assess the perceptions and capabilities of a pharmacy student cohort in pronouncing drug names.

The findings of this study demonstrated that the DrugSpeak programme could deliver significant improvements in drug pronunciation in terms of accuracy, suggesting an increased student proficiency in decoding and encoding drug names to generate verbal fluency. The study differs from many other pronunciation research articles in that it focuses on the pronunciation of single drug names rather than drug name recognition or recall, as is the case with LASA drugs. The quality of student pronunciation of short sentences and paragraphs has been assessed (Kennedy & Trofimovich, 2010), but even in this case, student

language awareness showed improvement, but not pronunciation skills. A recent study that aimed to produce continuous pronunciation quality assessments utilised a cloud computing model to compare student English pronunciations with reference word pronunciations in real-time (Zhao & Jiang, 2021). While these represent an attempt to provide general improvements in student verbal English performances, the DrugSpeak program focuses on drug name pronunciations as an essential graduate attribute that is specific to future health professionals.

DrugSpeak also produced almost identical increases (~18%) in student proficiencies in pronunciations of drug names that were included in the course learning material (Treatment drug set), as well as in drugs not included in the course (Untreated set). This result may have been driven by a global enhancement of student strategies in drug pronunciations rather than improvements in drug names that are more familiar. Nonetheless, some item-specific effects from exposure can be argued as the Treated drug names had higher chi-square values, suggesting a greater effect. Interestingly, students showed even more increases (27%) in pronunciation ability for drugs not yet on the market and unfamiliar to them (New Word set), but these increases were found to be insignificant. Again, this response is likely due to non-specific increases in skills. However, only ten drug names were included in the New word set, and research has revealed that small sample size may influence research outcomes, which could produce a non-significant increase, contrary to observation (Faber & Fonseca, 2014).

Factors such as student gender or native language were not primary parameters of focus in this report. Studies are inconclusive on gender since pronunciation ability is multifactorial (Brantmeier *et al.*, 2007; Richter, 2018). One may assume that native language may influence drug pronunciation ability; however, all students are



required to meet minimal English language levels upon entry to university. Furthermore, drug names hold a cross-similarity to the English language as there are no drug names that fall outside the (approximately) 45 sounds produced in the English language (Ogden, 2017). Beyond individual sounds, the concepts of syllables and prosodic stress at the word level are universal, albeit varying from language to language. Furthermore, the predominant native language was English in this study. As such, future studies analysing the influence of native language and gender are warranted in a larger dataset. For example, it would be interesting to conduct a DrugSpeak intervention focusing on cross-linguistic (etic) differences in drug pronunciation perceptions and capabilities and compare them to a study among participants of one culture (emic).

In the present study, it is assumed that factors outside of gender and native language are likely to have more impact on the drug pronunciation perceptions and abilities that were reported. One example may include prior learning, such as phonetics training in secondary schooling, and student motivation and attitudes towards the importance of correct drug pronunciations in their desired careers.

Students were surveyed on six paired questions on their perceived confidence, anxiety, learning ability, and competence of other health professionals in terms of drug pronunciation, both before and after the DrugSpeak programme. Only questions pertaining to student confidence and learning ability showed significant improvements following DrugSpeak, indicating that DrugSpeak equipped students with the strategies and approaches they needed for correct drug pronunciations, translating to increased student confidence and ability to learn in this regard. This result is supported by the data in this study, which showed increases in student drug pronunciation accuracy. Indeed, higher levels of student self-confidence lead to enhanced performances and increased positivity in problem-solving (Bandura, 1993; Oktafiani & Yusri, 2021). Contrastingly, statistical differences were not observed for questions relating to the importance of drug pronunciation and competencies of other health professionals, likely due to the high baseline levels of these perceptions prior to intervention with the DrugSpeak programme, revealing the generally high level of value placed on drug pronunciations by pharmacy students even prior to the use of DrugSpeak.

The overall feedback from students on the DrugSpeak programme was very positive. Most participants agreed that it increased their knowledge of phonetics and their confidence in drug pronunciations. Additionally, students recommended DrugSpeak be

incorporated into the curricula of the course for future students and even introduced into the coursework of other health degrees. The authors have integrated DrugSpeak into the postgraduate degree teaching curriculum and seek to further broaden its impact by incorporating it into the Medicine and Nursing degrees. Ultimately, it is anticipated that this programme will reduce the frequency of medication errors within the health sector, with enhancements in health practitioner fluency leading to higher patient satisfaction and quality of care (Diamond *et al.*, 2019).

Further complications arise in spoken pronunciations of drug names due to the requirement for health professionals to wear surgical masks (Smetzer & Cohen, 2001). This factor is more prominent than ever, given the emergence of the Covid-19 pandemic. Since masks obscure the mouth, reduce voice projection, and reduce articulatory clarity to a degree, they add to the confusion of specific drug medications uttered by the mask-wearers (Beyea, Hicks & Becker, 2003). This issue is further hampered by the noisy work environment and other distractions that are common in crowded pharmacies and various clinical settings (Lambert *et al.*, 2010; Pham *et al.*, 2011; Emmerton & Rizk, 2012), where clear, precise verbal drug communication practices are essential. Drug pronunciation programmes such as DrugSpeak seek to provide further assistance in this regard to prevent medication errors that arise from mispronounced drug names.

### **Limitations**

As the DrugSpeak programme was a pilot study, there were several limitations to this study that should be addressed in future iterations of the intervention. Firstly, a control group of students who possess minimal exposure to drug names (e.g., students enrolled in programmes unrelated to medicines) may help determine the effects of the programme on drug pronunciation. Secondly, prior exposure of students to drug names through popular culture, advertising, previous drug-related work or study, own prescription, and drug use or awareness may all contribute to baseline proficiencies in drug pronunciations. These factors should be accounted for when collecting sociodemographic data in the future. Thirdly, levels of student exposure to drug names between the first and second audio recordings should be standardised, as this is likely to directly influence student performances in the second recording. This matter may be difficult to control, as it is dependent upon student motivation and attitudes towards drug pronunciations. A possible way to remedy this issue is to conduct the final audio recordings immediately following the DrugSpeak workshops rather than during the last week of the course.

## Conclusion

The DrugSpeak programme was a pilot study that sought to address deficiencies in student drug pronunciations within a cohort of pharmacy students. The findings indicate student awareness of the need to address this problem and that the programme increased their confidence and reduced their anxiety in terms of drug pronunciation proficiency. Audio recordings revealed significant increases in student drug pronunciation performances in terms of accuracy and fluency, particularly for drug names that were studied in the course and unfamiliar drug names. Further studies will be aimed at testing DrugSpeak in other health-related degree programmes to further examine its effectiveness, extensibility, and ability to reduce medication errors in the health sector.

## Competing interests

The authors declare no competing interests.

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## Authors' contributions

DD conducted the experimental analysis and EC delivered the DrugSpeak workshop. MC and SA collected the data, and MC was a major contributor in writing the manuscript. All authors were involved in the original idea and project design, and well as the proofreading and approval of the final manuscript.

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