https://doi.org/10.37420/j.ial.2025.004

Examination of the Prevalent Biases in Digital Composition of Chinese Characters

Shubin Li

School of Foreign Languages, Tianjin Chengjian University, Tianjin 300384, China

Abstract

The present study meticulously reviews the literature concerning the biases in "electronic scripting of Chinese characters" from 2016 to 2024. It synthesizes the research findings, methodologies, and conclusions from prior inquiries into the biases associated with electronic scripting. The review indicates a primary focus within the research community on the taxonomic categorization, determinants, and pedagogical strategies, with the methodology targeting predominantly the categorization system and the influencing factors. The analysis reveals that the focus of research is centered on the categorization system, determinants, and pedagogical strategies, with a preference for a combination of quantitative and qualitative methodologies. The conclusions of these studies have evolved from straightforward typological analysis to an exploration of underlying and effective teaching approaches. Nevertheless, the sample population in these studies lacks generalizability, the impact of cultural context on students' biases in "electronic writing mechanisms" has not been thoroughly investigated, and there is a deficiency in longitudinal tracking of learner's progress over time. To enhance the applicability of the findings to a broader demographic, future research could incorporate questionnaires, interviews, and longitudinal studies.

Keywords: e-writing; Chinese characters; errors; second language acquisition; teaching strategies

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

1 Introduction

With the development of multimedia, the status of intelligent equipment in teaching is increasing, and electronic learning (electronic Writing, e-writing) came into being, and gradually became a new model and new demand in language acquisition and teaching (Xie, 2008, 2014). Entering the post-epidemic era, simple handwritten Chinese characters can no longer meet the requirements of teachers and students for learning efficiency. Many scholars predict that "paperless" learning will become a general trend (Yang and Zhan, 2024:52). In this context, the hypothesis that input methods promote Chinese character acquisition has been repeatedly mentioned, but early studies only focused on the auxiliary functions of the electronic writing mode and failed to fully explore its application value in acquisition. This limitation triggered the academic community to discuss the new paradigm of "electronic writing", and began to compare the differences in the implementation of handwritten Chinese characters and electronic writing Chinese characters. The focus has gradually shifted to "how to promote acquisition". In 2022, several cloud conferences held on the theme of "Chinese Character Teaching in the Electronic Writing Era" are not only a milestone in the internationalization of the electronic writing model, but also the first large-scale attempt to combine electronic writing theory with practice. The strategy of "electronic writing as the main method and handwriting as the auxiliary method" (Zhai, 2024; Chu, 2024) emphasizes the core role of electronic writing in Chinese character acquisition and teaching. While it has been widely recognized, it also marks the beginning of the systematic and in-depth development of research in this field, providing an empirical basis for future theoretical frameworks.

Different from the observation channel of handwriting errors, errors in electronically written Chinese characters focus more on the errors caused by emerging electronic products (such as mobile phones and computers) in the process of Chinese character input and recognition. Xie (2005) of California State University, Long Beach (CSULB) has analyzed the errors and causes of Chinese phonetic input since the beginning of the century. In the past decade, the field of Chinese teaching has gradually used electronic writing and typing as the main teaching method. Related research has begun to focus on the errors caused by electronic writing of Chinese characters, digging deep into its mechanism and building a corresponding theoretical system to meet application needs. After a comprehensive analysis of existing literature, it is found that previous studies have explored errors in electronic writing of Chinese characters from multiple dimensions and constructed a preliminary framework that covers the types of errors, influencing factors and teaching strategies. These articles are mainly from universities such as Beijing Language and Culture University, Guangdong University of Foreign Studies, Vassar University, and Michigan State University. The keywords revolve around "spelling", "electronic writing", "errors", "teaching" and "students", revealing the new characteristics of Chinese character acquisition in the electronic writing environment.

In addition, the research of Chen (2016) and Jiang (2017) showed that there is a significant correlation between electronic writing input and Chinese character acquisition. On the one hand, electronic writing can promote Chinese character processing and acquisition; on the other hand, electronic writing of Chinese characters can not only accelerate the process of Chinese character acquisition, but also provide an effective window for observing the error mechanism.

2 Literature Review

"Electronic writing" refers to the process of typing Chinese characters on a computer (or mobile phone) or inputting Chinese characters by voice, and displaying Chinese characters on the screen without "writing Chinese characters" (Lu, 2024: 3). From the name change from "spelling" to "electric typing" and then to "electric writing", we can observe the evolution of Chinese character input technology and the innovation of teaching practice. At first, the term "spelling" mainly referred to the fact that Chinese character input based on the pinyin input method must be completed through two steps: phonetic input and glyph recognition. With the development of science and technology, people began to pay attention to the fact that Chinese

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

character input is not only a matter of means, but also the interaction between equipment, platform and people. Therefore, the term "electric writing" came into being. It not only includes the operational characteristics of spelling, but also includes the importance of equipment in input. It also emphasizes the handwriting input and voice input brought about by technological updates (Shi and Ji, 2024), and at the same time points out the development path from word acquisition to discourse acquisition.

Regarding the definition of electronic writing errors, different scholars have proposed different definitions from their respective research perspectives. Chen (2016) mentioned that electronic writing errors mainly refer to the errors made by international students when using smart electronic products to input Chinese characters, reflecting the common errors in Chinese character recognition and input in the electronic writing environment. Although Jiang (2017) did not directly define electronic writing errors, he proposed the combination of handwriting and electronic writing input, which also hinted at the relationship between handwriting errors and electronic writing errors. Che (2023) summarized electronic writing errors as Chinese character errors caused by students' cognitive differences or operational errors in the process of spelling Chinese characters. Combining the above viewpoints, we can give a more comprehensive definition of electronic writing errors: electronic writing errors are errors made by students when inputting Chinese characters in an electronic writing environment. The errors involve multiple levels of cognition, means, and equipment, reflecting students' deficiencies in Chinese character cognition and application.

3 Research Design and Methods

3.1 Type research

The existing electronic Chinese character error system can be roughly divided into four categories: pronunciation errors, character shape errors, input method association errors and other errors.

3.1.1 Pronunciation errors

In the literature on errors in electronic writing, pronunciation as a key point covers errors in finals, initials and "er". Its complexity lies in the variety of types and high difficulty in judgment (Chen, 2023; Zhai, 2024), which is particularly common in the primary stage. Among them, errors in finals are significant and often associated with pitch differences, specifically manifested as confusion between front and back nasal sounds. Thanks to the uniqueness of electronic writing input, the error mechanism of the erhua final "er" is highlighted: studies have found that "er" is often typed with the previous syllable as r, resulting in confusion between "儿" and "人", or it cannot be typed without being restored to "er" and is simply "abandoned" by students (Chen, 2016; Chen, 2013). These phenomena also provide a new perspective for examining the special pinyin mechanism of error correction. Compared with errors in finals, errors in initials often involve errors in sound length and pronunciation position, such as confusion between front and back sounds at the tip of the tongue (Chen, 2016). The above fully reflects the physiological characteristics contained in acquisition errors. In addition, the cognitive errors pointed out by physical features are not limited to oral learning. For example, the substitution of words or syllables with similar pronunciations also occurs in electronic writing environments. It is worth noting that these errors do not exist in isolation. They are closely related to the age group, native language background, and level of the learners.

3.1.2 Font errors

Turning to the shape error, it is the most frequent type of all errors, including errors of homophones with similar shapes, homophones with different shapes, and heterophones with different shapes (Zhai, 2024). In particular, homophone/word errors account for a considerable proportion in later learning, and the distribution characteristics also echo the error pattern of handwritten Chinese characters. Pinyin dependence, as a common phenomenon among beginners, can expose the shortcomings of shape recognition. Once students are required to "type by looking at the characters" without the assistance of pinyin, the shape substitution

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

errors will increase significantly, but in comparison, the shape errors are still effectively controlled in the "electronic writing" environment (Chen, 2016). Turning to the structural perspective, shape errors are further broken down into component errors and planar diagram errors (Chen, 2023), that is, component combination errors of compound characters. Compound characters are often "deleted" by students into single characters, and the phenomenon of "mutual substitution and mixing" between different radicals also often occurs. Whether the error characters are familiar characters or new characters, students will be confused. In his research, Zhai (2024) creatively paid attention to the confusion between simplified and traditional Chinese characters, which mainly exists among overseas Chinese students with a Chinese character background. This finding provides a sample for exploring the complex mechanism of electronic writing errors.

3.1.3 Input method errors

This type of error is unique to electronic Chinese writing. Common errors include misleading associations, incorrect input of connected sentences, and missing empty characters. All of the above phenomena reflect that students have an avoidance mentality in the learning process (Chen, 2016). Specifically, elementary-level students are unable to be compatible with the intelligent association function of the input method. When inputting, they may be influenced by the system's recommendations and choose inappropriate vocabulary or phrases. In addition, incorrect input of connected sentences also occurs from time to time. Some students will input a whole sentence at a time without careful proofreading, resulting in confusion of meaning groups or grammatical errors. In fact, this is also a sign that students are overly dependent on the input method. Finally, most of the missing empty characters are because students fail to master the target characters and choose to use spaces as placeholders. A small part is due to accidental keyboard touches, especially when the virtual keyboard is not strong enough to operate, it is more likely to produce such errors (Spilling, Rønneberg, Rogne, Roeser, Torrance, 2022). However, it is speculated that it may also be because European and American students are influenced by the English input habit and subconsciously put spaces between characters or words, resulting in missing empty characters.

3.1.4 Other biases

These errors are relatively trivial, with an irregular frequency of occurrence, and they present different forms at different stages. For example, semantic errors and grammatical errors are common among young students in the initial stage of learning. Students have not yet mastered the rules of the target language or overgeneralize them, and use participles inappropriately, omit Chinese characters, or use redundant phrases (Zhai, 2024). According to Chen's (2023) study of college students in the initial stage of learning, phoneme addition and subtraction errors are even more variants of the phenomenon of overgeneralization, which indirectly reflects the difficulties students have in acquiring phonetics. Overgeneralization is not limited to the lexical level but also reflected in grammatical structures, such as the loss of medial, which together constitute a diverse network of errors in electronically written Chinese characters.

3.2 Research on influencing factors

On the one hand, mother tongue transfer is more common among international students in the initial stage of learning. Because of their first contact with Chinese, students will directly embed their mother tongue thinking mode and even the writing form of their mother tongue into Chinese, resulting in the phenomenon of replacing radicals. At this time, they do not follow the set rules, but spell according to their own habits. Once they encounter unfamiliar Chinese characters in practice, they will replace them with Chinese characters with the same or similar pronunciations. This "replacement" phenomenon is actually a transfer within the Chinese language. On the other hand, there are also positive and negative transfer effects in the cognitive mechanism that affect the acquisition of Chinese characters, and are closely related to the complex process of memory processing. Among them, metalinguistic awareness has a positive impact on the distinction between phonetics, components and compound morphemes (Chen, 2023). Yang (2024) and others have

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

confirmed that under certain conditions, electronic writing is conducive to reducing the fear of second language students in learning Chinese characters and promoting their Chinese character cognition.

Finally, improper teaching strategies can also lead to errors in electronic writing. Due to the particularity of electronic writing, the errors caused by this influencing factor run through almost every teaching link, and the frequency of occurrence is disordered and the form is difficult to predict. In the initial stage, some teachers overemphasized the accuracy of spelling word by word. This teaching orientation inadvertently prompted students to disassemble compound words and even split and input complex Chinese characters one by one, which gave rise to a large number of literacy and spelling errors. Such errors actually directly reflect the lack of teacher experience and prove that refined strategies are very necessary. In addition, defects in textbook design are also one of the causes of errors (Chen, 2016). At present, there is a lack of clear operational guidelines for easily confused or special pinyin such as “er” and “u”, which undoubtedly increases the difficulty of learning. At the same time, there is a lack of teaching resources based on large-scale corpora, and it is difficult for teachers to foresee the difficulties that students may encounter, and it is difficult to provide guidance and adjustments in a timely manner; if students’ language foundation is not solid, teachers blindly increase the amount of electronic writing tasks, which will only increase the students’ cognitive burden (Zhai, 2024). This “quantity accumulation” rather than “qualitative improvement” directly leads to an increase in the error rate.

3.3 Teaching strategy research

The teaching strategies for errors can be roughly summarized into three dimensions: content, methods, and application. In terms of content optimization, first, we should focus on the recognition of pronunciation and design various exercises to consolidate the connection between pronunciation, shape, and meaning of students, so that students can be familiar with the processing mechanism of Chinese characters that is different from that of phonetic characters. Second, we should focus on the key role of components and radicals in the recognition of Chinese characters (Zhai, 2024). At the same time, Chen (2016) also proposed to use the “learning accompanies and using accompanies” phenomenon generated by the context and Chinese characters in the learning process to enhance the interactive effect with students to promote learning; simultaneously create a “word” context, integrate Chinese characters into the local context of the language for learning, and read them multiple times in series with the context to reduce the rate of character recognition errors. In general, there should be less error correction in the initial stage, and rich context information should be reconstructed to “accompany” the learning of Chinese characters to reverse potential teaching errors.

In terms of method innovation, some scholars have proposed to introduce the principle of separating the recognition and writing of handwritten Chinese characters to separate the recognition and writing of electronically written Chinese characters (Jiang, 2017), indicating that breaking down complex tasks to allow students to focus on a single skill can reduce the difficulty of learning. Secondly, the study takes into account the importance of artificial shape recognition awareness and ability for Chinese character learning. It not only follows the path of phonetic training being regarded as enhancing shape recognition ability, but also expands the guiding role of phonetic indicators, which is convenient for urging the integration of example sentence corpora of electronically written Chinese character errors for teaching intervention (Zhai, 2024).

In terms of application, we should focus on the preparation and introduction of electronically written Chinese characters using computers, mobile phones and other electronic devices, and then introduce Chinese character functional components in a timely and appropriate manner in the electronic writing-based mode, keeping handwriting as an auxiliary role in electronic writing. Teachers should also release the teaching function of pinyin and make good teaching designs for pinyin typing.

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

3.4 Experimental method study

The research on errors in electronic writing is relatively traditional in experimental methods and is in its infancy. Most of the research subjects are Chinese beginners in European and American countries, and the investigation period is relatively short, ranging from one to six months. Most of the selected corpora have been pre-designed teaching links and teacher intervention, and then obtained through homework and daily evaluation. In the data processing stage, the annotation results and the above-mentioned data processing methods were used to ensure the accuracy of the data and the effectiveness of the analysis (Zhai, 2024). In the process, the collected error examples were classified, annotated and statistically analyzed, and the common error types and causes of students in the process of learning Chinese were analyzed.

4 Comments on Previous Studies

4.1 Review of type studies

In the study of types, previous studies have focused on introducing different dimensions and comparing with traditional Chinese character errors, constructing a more intuitive error type system, highlighting the general mechanism of Chinese character errors and the unique characteristics of electronically written Chinese characters. And taking into account the special errors caused by electronic writing equipment. However, the disadvantage is that the inductive boundary of errors is vague. Many special errors have not been discussed separately, but are only unilaterally classified from the perspective of shape and sound. For example, previous studies have not discussed whether the voice input link of electronically written Chinese characters will produce tone errors. Tone is a major difficulty for Chinese students to learn Chinese characters (Fang and Ren, 2024), and students in the electronic writing environment do have character shape errors caused by tone. In addition, the erhua sound, as one of the difficulties for Chinese students to learn Chinese characters, has not received enough attention. Its error forms are complex, which reflects that students do not have enough knowledge of morphemes and that they are not very clear about the input principle of electronic writing equipment.

4.2 Review of research on influencing factors

Based on the current research on the factors affecting electronic writing errors, it can be found that the interdisciplinary perspective is more prominent. Researchers have analyzed the principles of electronic writing errors from multiple dimensions such as linguistics, psychology, and education, showing a dynamic and progressive view. The shortcomings are that the causes of some errors are only inferred based on morpheme knowledge, and students are rarely asked why they miss or make mistakes when typing; the research on the path of mother tongue transfer is not in-depth. Taking beginners in Europe and the United States as an example, it does not consider how English letter combinations affect the occurrence of errors such as confusion and omissions in electronic writing of Chinese characters. In addition, it does not consider whether there is a Chinese character background, different teaching scenarios, and various types of Chinese texts will present what kind of error types and their characteristics and trends.

4.3 Review of research on teaching strategies

Previous studies on teaching strategies for electronic writing errors have consciously introduced an interdisciplinary perspective and fully considered the relationship between the brain and electronic writing errors (Cui, 2024; Yang and Zhan, 2024). Strengthening the structure of electronic writing Chinese characters, improving the accuracy of recognition and memory, also enhances students' ability to apply Chinese characters in practice. At the same time, the study also realized the connection between platform interactivity and students' sense of participation and motivation (Zhai, 2024), actively introduced the teaching principles of handwritten Chinese characters to assist electronic writing learning, and set up localized teaching strate-

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

gies that can be adjusted at any time according to students' specific needs. However, there are also some incomplete considerations. For example, building an effective context and innovating teaching methods may require additional teaching resources, more professional training and teaching design capabilities, which is a challenge for schools and teachers and may also increase the cost of education. In addition, relying on teaching strategies to suppress errors is still dominated by teachers, and it does not focus on what students can do in the process of discovering and solving errors, and guiding the compilation of teaching materials is not on the agenda. More importantly, as electronic devices are a key part of electronic writing, their performance differences may affect learning outcomes. How to solve the accessibility and consistency issues in different regions and under different economic conditions also needs further discussion.

4.4 Review of experimental methods research

Different from the error research of traditional Chinese character acquisition, the error research of electronic Chinese characters is mainly quantitative, and is supported by empirical evidence and data. The corpus is collected through daily practice, which is authentic and reliable. Moreover, the collection is not limited by time and space, and the forms are diverse, which makes it possible to highlight the new errors that have not been discovered in the traditional handwritten Chinese character error research, and facilitates the exploration of the relationship between modern technology and Chinese character teaching. What needs to be paid attention to is that the means selected in qualitative research are relatively simple, and the root causes of students' errors are rarely explored through observation, questionnaires, conversations, etc., and there is no long-term follow-up survey of students to observe the changes in error types with learning progress. It only describes its appearance through case and comparative analysis methods, and the collected corpus does not indicate which type of examination questions are used to obtain it. The researchers have no way to judge whether the error types and influencing factors are objective in the analysis, and the correspondence between each error and the Chinese proficiency stage is poor. In addition, the language background, age group, and level stage of the research subjects are relatively simple, and it is impossible to explore the relationship between these three and the error types. The collected corpus does not specify the type of examination questions used to obtain it. The researchers have no way of judging whether the analysis of error types and influencing factors is objective, and the correspondence between the various errors and the Chinese proficiency levels is poor.

5 Conclusion

After an in-depth analysis of the existing literature, the following conclusions were drawn: First, the types of errors in electronically written Chinese characters are mainly pronunciation errors, character shape errors, input method errors, and other errors. The types show stage characteristics, and the structural system is clear but not very targeted. Second, the influencing factors of electronic writing errors include mother tongue transfer, cognitive processing, and improper teaching strategies. Previous studies have adopted an interdisciplinary perspective but have poor depth and tendency. Teaching strategy research is roughly divided into three dimensions: content, method, and application. It focuses on practicality and memorization efficiency, but the participation of other subjects in the teaching process is not high. Third, the experimental method prefers to collect corpus in advance and then annotate the comparison results. The quantitative support is strong, but the universality and objectivity need to be observed. Future research should be committed to expanding the country diversity of samples, focusing on analyzing new types and new forms of electronically written Chinese character errors, especially those special errors caused by electronic writing interface interactions. At the same time, mixed experiments should be designed to combine quantitative data with qualitative interviews to reveal the deep reasons behind electronic writing errors, design more refined teaching strategies, and enhance the application value of electronically written Chinese characters in reality.

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

CRediT authorship contribution statement

Ms. Shubin Li finished the study solely.

Declaration of Generative AI and AI-assisted technologies in the writing process

The author declares that no Generative AI or AI-assisted technology was used in the study.

Declaration of competing interest

The author declares that she has no competing interests.

Data availability

The datasets generated and analyzed during the current study are available from the author on reasonable request.

References

Chen, M. (2023). Analysis of the types, characteristics and influencing factors of Chinese character spelling errors made by American elementary learners. Chinese Character Culture, (1): 141-147.

Chen, Y. (2016). Error analysis and teaching strategies of "spelling and typing" Chinese characters: zero-starting Chinese character teaching based on smart electronic products. Chinese Learning, (1): 84-94.

Chu, C. (2024). Developing Chinese second language teaching through the teaching transformation of "electronic writing as the main method". https://b23.tv/kaT1NOE, 2024-08-01/2024-10-13.

Chu, C., Liang, N., Lu, X., Qian, Z., Wang, Q., Wang, X., & Zhang, X. (2024). Roundtable discussion on Chinese character teaching in the era of electronic writing. https://b23.tv/0nOObfL .

Cui, X. (2024). The influence of "handwriting" and "electronic writing" on Chinese character learning and related research perspectives. Journal of Yunnan Normal University (Teaching and Research on Chinese as a Foreign Language), 22 (5): 11-19.

Fang, Y., & Ren, L. (2024). Research on the tone of Chinese learners in Pakistan and teaching suggestions: Taking "bu" and "yi" as examples. Chinese Character Culture, (17): 163-168.

Jiang, X. (2017). Chinese character teaching in the keyboard era. International Chinese Teaching Research, (2): 4-10.

Lu, J. (2024). Typing Chinese characters leads the way, followed by writing Chinese characters: Innovating the Chinese character teaching model in international Chinese education. Journal of Yunnan Normal University (Teaching and Research on Chinese as a Foreign Language), 22 (4): 1-5.

Shi, F. & Ji, Z. (2024). Electronic writing of Chinese characters is the general trend of the information age. Journal of Yunnan Normal University (Teaching and Research on Chinese as a Foreign Language), 22 (4): 6-11.

Spilling, E. F., Rønneberg, V., Rogne, W. M., Roeser, J., & Torrance, M. (2022). Handwriting versus keyboarding: Does writing modality affect quality of narratives written by beginning writers?. Reading and Writing, 35(1): 129-153. https://doi.org/10.1007/s11145-021-1069-y.

Xie, T. (2014). Chinese teaching keeps pace with the times. International Chinese, (1): 69-74.

Xie, T. (2008). Computer teaching is the only way to make it a daily routine. Chinese Teaching Modernization Society. Progress and deepening of digital Chinese teaching. California State University, Long Beach, USA: 7.

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)

Xie, T. (2005). Error analysis of Chinese Input in Chinese learning. Ping Xu and Theresa Jen Chinese Character Teaching and Computer Technology. Taipei: Department of Education.

Yang, Q. & Zhan, Z. (2024). “Handwriting” or “typing”? Mechanisms and evidence of the influence of writing style on cognitive learning. Open Learning Research, 29 (1): 52-62.

Zhai, N. (2024). Innovation and practice of Chinese character teaching model in the era of electronic writing: A case study of errors in “electronic writing” by Canadian primary school students. Journal of Yunnan Normal University (Teaching and Research on Chinese as a Foreign Language), 22 (4): 19-28.

Zhang, N. (2024). L2 New Path for Chinese Character Teaching: Review, Reflection and Prospect of the Effectiveness of Electronic Writing Teaching. https://b23.tv/dYYTPsk, 2024-08-01/2024-11-01

© By the author(s); licensee Mason Publish Group (MPG), this work for open access publication is under the Creative Commons Attribution International License (CC BY 4.0). (http://creativecommons.org/licenses/by/4.0/)