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Discovery Learning-Based Worksheets as a Tool for Enhancing Science Process Skills and Environmental Literacy in Middle School Students

Sry Ariyanti A. Muthalib[1]*, Nurasyah Dewi Napitupulu[2], Muslimin[2], Marungkil Pasaribu[2], I Komang Werdhiana[2]

[1] Program Studi Magister Pendidikan IPA, Sekolah Pascasarjana Universitas Tadulako, Palu, Indonesia
[2] Program Studi Pendidikan Fisika, Universitas Tadulako, Palu, Indonesia

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Corresponding Author:
Sry Ariyanti A. Muthalib
sryariyanti13@gmail.com

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Abstract: The aim of this study is to develop Discovery Learning-based Learner Worksheets (LKPD) using the ADDIE model with the objective of enhancing the science process skills and environmental literacy of secondary school students. This research employs a one-group pretest-posttest design within the context of a research and development (R&D) project conducted in class VII of SMP Negeri 2 Bungku, comprising 29 students, of whom 13 are male and 16 are female. The research instruments included validation sheets, Discovery Learning-based learner worksheets, observation sheets for science process skills, environmental literacy tests, and questionnaires for teachers and students regarding their responses to the product. The results demonstrated the validity of this development, with a score of 88%, a figure that was additionally supported by the teacher response score, which fell within the "very practical" category. The product of this development has a positive effect on students' science process skills, with an N-gain of 0.60 in the moderate category, indicating a significant improvement. The effect size of 0.47 in the moderate category indicates that this improvement is very significant. Furthermore, the development results had a significant impact on students' environmental literacy, with an N-gain of 0.35 in the medium category. The effect size of environmental literacy was 0.47 in the medium category.

Keywords: Discovery Learning, Worksheet, Science Process Skills, Environmental Literacy

Introduction

The development of science and technology has brought about significant changes to the domain of education, resulting in an urgent need to update teaching methods and approaches. The issue of environmental literacy, which concerns the understanding of the relationship between humans and the environment and the capacity to make sustainable decisions, has become increasingly urgent on a global context. The challenges of climate change, pollution and loss of biodiversity are key issues facing the current generation of young people (Arneth et al., 2020). The development of strong environmental literacy can assist students in gaining an understanding of the complexity of these issues and in contributing to the development of sustainable solutions (Arneth et al., 2020; Häggström & Schmidt, 2020). Research findings highlight the necessity of incorporating environmental literacy into the school curriculum in order to equip students with the

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knowledge and skills required to address global environmental challenges.

In addition to environmental literacy, the development of science process skills is of paramount importance in modern education. These skills, which include the competencies of observation, classification, measurement, and analysis of data, are critical for comprehending scientific concepts and applying them in everyday life. Students who possess strong science process skills tend to demonstrate a more in-depth understanding of scientific material and are better positioned to engage in critical thinking when confronted with challenges (Tom Russel, 2023). Research findings suggest that science process skills can be enhanced through interactive, discovery-based learning approaches.

The urgency of developing environmental literacy and science process skills is contingent upon the necessity of preparing students to effectively confronted the future challenges that they will inevitably face (Amin & Maritasari, 2023; Maulana et al., 2023). The development of scientific abilities and environmental literacy is crucial for the construction of a generation that is equipped with the necessary skills to adapt to the technological and environmental changes that the future will undoubtedly bring (Guerrero & Sjöström, 2024; Hanifha et al., 2023). Students who have participated in training programs that develop their science process skills tend to show enhanced abilities in problem-solving and innovation. Accordingly, the objective of this research is to develop and evaluate the efficacy of student worksheets (LKPD) based on discovery learning, with the aim of enhancing students' science process skills and environmental literacy, thereby addressing the crucial need for education that is contextually relevant to the current global challenges.

Prior research has demonstrated that discovery-based learning can enhance students' engagement and comprehension in the field of science education (Afrianti, 2022; Roheni et al., 2020). This method encourages students to assume an active role in the learning process, requiring them to utilize independent research and investigation to develop a more profound understanding of the subject matter. A body of research indicates that students engaged in discovery-based learning demonstrate higher levels of engagement than those who follow conventional learning methods (de Jong et al., 2023). Furthermore, this approach enables meaningful engagement, enabling students to actively participate in discussions and engage in critical reflection on the subject matter (Roheni et al., 2020). Discovery-based learning has been demonstrated to be an effective method for developing students' cognitive abilities, including critical thinking and problem-solving skills (Elvani et al., 2024; Muhayati et al., 2023; Nabilla et al., 2022). Moreover, it allows students to connect scientific concepts with real-world scenarios (Chusni et al., 2020; Ouzzine et al., 2022), thereby enhancing their cognitive abilities to comprehend and utilize novel knowledge (Nursakinah & Suyanta, 2023). Furthermore, this approach has been shown to positively impact students' motivation and social skills, fostering cooperation and communication (Fatimah & Rohani, 2022; Nainggolan & Purwaningsih, 2024; Nurasyah, 2022; Tanjung & Louise, 2024).

Nevertheless, as various studies have demonstrated, discovery learning offers significant advantages. However, its application in developing student worksheets (LKPD), particularly in the context of science and environmental literacy, remains an area that requires further investigation. Discovery learning-based LKPD has the potential to be an effective tool for helping students develop science process skills and environmental literacy. By integrating activities that encourage discovery and investigation, LKPD can become a more interactive and in-depth learning medium.

The originality of this research lies in its focus on integrating environmental literacy into discovery learning-based LKPD. Although numerous studies have examined the use of discovery learning in conjunction with science process skills, few have focused on the particular objective of enhancing environmental literacy through this approach. This research addresses this gap by developing LKPD that not only improve science process skills but also foster a deep understanding of environmental issues and sustainable decision-making.

As one of the pioneering secondary schools in Indonesia, SMP Negeri 2 Bungku has significant potential to implement this educational innovation. An initial survey revealed that while students at this school showed high interest in science lessons, their science process skills and environmental literacy needed improvement. Therefore, this research aims to develop and test the effectiveness of discovery learning-based LKPD in enhancing the science process skills and environmental literacy of class VII students at SMP Negeri 2 Bungku.

This research contributes to the development of effective learning tools in a practical sense, while also offering insights into the theoretical application of discovery learning in science and environmental education. The objective is to provide a reference for educators and researchers in the development of innovative and effective learning methods that incorporate environmental literacy as a fundamental element.

Method

The research paper discusses a Research and Development (R&D) using the ADDIE model (Molenda, 2003), which focused on developing Student Worksheets (LKPD) based on discovery learning (Fig. 1). The study was conducted at SMP Negeri 2 Bungku, Central Sulawesi, with seventh-grade students as the population. The sample selected through purposive sampling from 5 existing classes with a total of 141 students. The sample was determined on the basis of initial data from the Junior High School Entrance Test, where the population was homogeneous and not too geographically dispersed. The number of research subjects was 29, consisting of 13 males and 16 females.

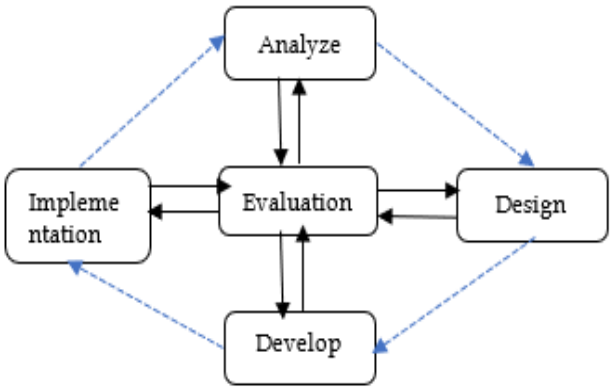

Figure 1. Developmen model ADDIE

Data collection techniques included observation, interviews, documentation, validation, surveys and written tests. Data interpretation was done descriptively for each science process skills indicator, and the results of the students' environmental literacy tests were analyzed using specific formulas and converted into environmental literacy criteria. The process of converting the results of the environmental literacy test and observation of science process skills into environmental literacy and science process skills criteria involved calculating the percentage score of each student's test performance, and then converting it into specific criteria based on predetermined intervals. The formula used for this conversion is shown in Table 1 (Suryawati et al., 2020).

Table 1. Science process skills and environmental literacy criteria

Score percentage %	Categories
1 - 20	Very Poor
21 - 40	Poor
41 - 60	Average
61 - 80	Good
81 - 100	Very Good

To measure the improvement in environmental literacy and science process skills, the study used a one-group pretest-posttest design by calculating the normalized N-gain according to Richard (1998).

Tabel 2. N-gain criteria of science process skills and environmental literacy

N-gain value	Criteria
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

The effect size of environmental literacy and science process skills was measured by comparing the pretest and posttest scores using the effect size formula according to (Andrew D. Cohen, 2005). The results of the calculations were converted into criteria for improving science process skills and environmental literacy, as shown in Tables 2 and 3.

Tabel 3. Effect size criteria of science process skills and environmental literacy

Score effect	Criteria
$d > 0.8$	Large
$0.2 < d \leq 0.8$	Medium
$0 < d \leq 0.2$	Small

Result and Discussion

This research aims to develop LKPD Indonesia's ecology and biodiversity based on Discovery learning to improve science process skills and environmental literacy. The results and discussion of this research are based on the EDDIE stages.

Analysis

The LKPD development process begins with a comprehensive analysis stage. This stage includes curriculum analysis, student analysis and material analysis. The objective of the curriculum analysis is to determine the curriculum used in class VII SMP Negeri 2 Bungku. The analysis is based on a comprehensive review of the curriculum documents at SMPN 2 Bungku. By analyzing the curriculum, we can identify the competencies that will be achieved through the material used. As stated by Maryanti et al. (2021), curriculum analysis is the process of identifying subjects and educational programs contained in the curriculum. This is done in order to evaluate the curriculum for further development, find existing deficiencies and problems, and produce the expected solutions/developments. This is done because it is not possible to provide all the competencies in the curriculum as teaching materials.

Student analysis determines the characteristics of students, including activity, understanding, skills,

learning styles, group work abilities, previous learning experiences, varied backgrounds and students' activeness towards the environment. This research obtained student analysis from student interviews. The student analysis clearly showed that science learning was difficult, full of theory and boring because it did not involve students actively. It is indisputable that students' active participation greatly influences the process of thinking, emotional and social development. Teachers can develop students' active learning in subjects by increasing student interest, arousing student motivation, and using media in learning. Student involvement in learning is the key to children actively getting involved in the learning process (Napitupulu et al., 2019).

The necessity for innovative solutions in the fields of learning ecology and biodiversity in Indonesia is becoming increasingly apparent. The identified solutions include the utilization of group discussion methodologies, the incorporation of supporting media such as PowerPoint presentations, video footage, discovery learning-based LKPDs and environmental literacy questions. In response to input from class VII science teachers, the selected solution was to provide training in science process skills using discovery learning-based LKPD. This research is aligned with the findings of numerous preceding studies, which underscore the significance of discovery learning in enhancing students' comprehension of scientific principles. For example, research conducted by Muhali et al. (2021) and Sukaisih (2023) concluded that guided discovery learning can enhance students' analytical and problem-solving abilities when compared to traditional learning methods. In this context, the utilization of discovery learning-based LKPDs facilitates the advancement of science process skills by affording students the chance to engage actively in the discovery and exploration of ecological and biodiversity concepts.

Furthermore, the utilization of learning media, including PowerPoint, videos and environmental literacy questions, serves to enhance the learning process. As Tenzin et al. (2022) and Ugwuanyi et al. (2020) have demonstrated, the use of visual media such as PowerPoint can facilitate students' comprehension of abstract concepts. Similarly, environmental literacy constitutes an essential element of ecological education, as evidenced by the findings of (Iskandar et al., 2023; Napitupulu, 2023). The latter study revealed that students' comprehension of environmental concerns improved when their learning was aligned with their daily experiences. Nevertheless, several studies indicate that the efficacy of the discovery learning approach is contingent upon its appropriate implementation and the provision of sufficient support by the instructor. For instance, (Lazonder & Harmsen, 2016; Öztürk et al., 2022) criticizing that discovery learning without adequate guidance can cause confusion and high cognitive load on students. Therefore, it is important for teachers to provide adequate scaffolding and ensure that students have sufficient guidance during the learning process.

Design

The subsequent phase is the design of the LKPD based on the principles of discovery learning. The preliminary version of the LKPD was structured into three principal sections: the introductory section, the central section, and the concluding section. The initial section comprises a cover page, foreword, table of contents, concept map, basic competencies, competency achievement indicators and instructions for use. The core section contains LKPD steps that adapt to the discovery learning model steps. The LKPD contains three materials: interactions between living things and the environment, human influence on the ecosystem, and conservation of Indonesia's biodiversity. The final section contains practice questions and a bibliography.

To improve environmental literacy and scientific process abilities, the LKPD is designed in five important parts. First, the discovery learning approach is crucial. For discovery learning to be effective, the LKPD must be designed with a clear structure and sufficient guidance. This includes step-by-step guides for experiments, questions that facilitate learning key concepts, and reflections to encourage deeper understanding. Scaffolding is essential in discovery-based learning to prevent confusion and overload, as noted by Aryani & Wahyuni (2020) and Masgumelar & Mustafa (2021).

Learning media such as PowerPoint should be utilized in the LKPD. These media should support and clarify important concepts. For instance, diagrams or animations about ecosystems or pollution can enhance students' comprehension of the material (Barz et al., 2024) highlight that effective visual media can significantly aid student learning.

Contextual environmental literacy questions must be included in the LKPD, relevant to the students' local context. These questions should cover knowledge of the environment, pollution, environmental issues, and problem-solving. Research indicates that learning about the environment can improve students' understanding and foster a greater sense of care for it.

The LKPD should focus on the skills needed to do science. It should help students practice essential science skills like observation, experimentation, data analysis, and problem-solving. All activities in the LKPD should aim to develop these skills. For example, students can

collect data on biodiversity in their school environment, analyze it, and write a report. Barz et al. (2024) and Syahgiah et al. (2023)) show that active involvement in scientific activities helps students better understand concepts and think analytically.

Feedback and reflection are vital components of the LKPD. There must be a mechanism for students to give and receive feedback. Learners need feedback on their performance and opportunities to reflect on their learning. This can be facilitated through discussions, presentations, or journals, helping students gain a deeper understanding and stay motivated to continue learning (Prasetya et al., 2023; Syahgiah et al., 2023).

The efficacy of the design using the discovery learning method in LKPD is supported by a substantial body of empirical evidence demonstrating its effectiveness in enhancing critical thinking and problem-solving abilities. For example, research conducted by Chusni et al. (2020); Roheni et al. (2020) indicates that discovery learning can enhance students' analytical capabilities. However, research conducted by (Amin & Sukenti, 2023) emphasize that the efficacy of discovery learning is contingent upon the level of guidance provided. In the absence of sufficient guidance, students may encounter confusion, which can impede their learning.

Development

At this stage, the LKPD is developed through discovery learning and is prepared for field trials. In this phase of the development process, activities are conducted to validate the material in question, including expert review, teacher assessment, individual trials, and small group trials. The expert validation process is conducted by two lecturers from the Science Education Study Program and the Postgraduate Master's Program at Tadulako University, who are designated as the "validator 1" and "validator 2," respectively. Subsequent to the review of the LKPD by the supervisor, validation is conducted. The validation results obtained from validator 1 yielded an average score of 3.5, corresponding to 88% in the valid category, with the incorporation of revisions. The average score obtained by Validator 2 in the "valid with revision" category was 3.5, representing 88% overall. The validation process encompasses a range of elements, including the material's alignment with the learning objectives, the clarity of the instructions provided, and the overall suitability of the material for the intended learning outcomes. The findings of this study are corroborated by Safitri & Mediatati (2021) and Nursakinah & Suyanta (2023) argue that clear and relevant instructions are crucial for the efficacy of discovery learning-based instruction. Nevertheless, the necessity for revision suggests that further enhancements are required, particularly in terms of providing more explicit instructions and ensuring greater alignment between the material and the student context.

At the teacher assessment stage, the discovery learning-based LKPD was evaluated by two science teachers at SMP Negeri 2 Bungku, Indonesia. The objective of the teacher assessment is to ascertain the suitability of the LKPD prior to conducting a field test. The mean score obtained from the two teachers' assessments was 4.43, representing a percentage of 89% in the 'very practical to use' category. The teachers' response to the LKPD was highly positive, with an average score of 89% indicating that they perceived this LKPD as an effective and user-friendly tool for teaching. Teacher support is a crucial factor for successful implementation in the classroom, as highlighted by Zhang (2022), who emphasize the importance of teacher involvement in technology-based learning and new methods. However, it is essential to ensure that teachers have received adequate training to make optimal use of these LKPD.

In the individual test, the mean score for the very practical category was 4.45, representing 89% of the total possible score. In the small group test, an average score of 4.33, or 87%, was obtained in the very practical category. This demonstrates that the LKPD is straightforward for students to use and comprehend, both individually and in small groups. Based on these findings, it can be concluded that discovery learning-based LKPD is effectively utilized in learning. This illustrates that the LKPD is accessible for students to utilize and comprehend, both individually and in small groups. The findings of the research demonstrate that practicality is a crucial element in the effective implementation of discovery learning. It is essential that students feel at ease and are able to comprehend instructions with minimal difficulty (Safitri & Mediatati, 2021).

Implementation

The results of the data analysis on the percentage of students' science process skills demonstrate a number of noteworthy patterns and their relevance in the context of science learning at the junior high school level. Firstly, it can be observed that there was a consistent increase from the initial meeting to the third meeting in all areas of science process skills (Tabel 4). The observation skills, which are fundamental competencies in science, demonstrated a notable enhancement from 67% at the inaugural meeting to 86% at the third meeting.

Tabel 4. The Science process skills result

Science process skills aspects	Percentage (%)			N-gain
	1st lesson	2nd lesson	3th Lesson	
Observations	67	83	86	0.58
Hypothesis	66	84	90	0.70
Classify	68	80	88	0.62
Predict	66	76	81	0.45
Communicating	66	76	89	0.68
Conclude	66	78	85	0.58
Average	66	80	86	0.60

This demonstrates that the implementation of discovery- based learning in LKPD is an effective method for developing students' abilities to observe natural phenomena and record them in a more meticulous manner (Logan Fiorella, 2013; Napitupulu et al., 2018; Napitupulu et al., 2019). The N-gain is 0.60, which falls into the "medium" category. This increase indicates that this method is effective in improving students' science understanding and skills. Furthermore, research by Nismidawati et al. (2022); Yonchai et al. (2023) demonstrated that discovery- based learning enhanced students' analytical and problem-solving abilities, which aligns with these findings.

The Science process skills aspect that showed the highest improvement was the skill of formulating hypotheses, a percentage increase at the first meeting to the third meeting with N-gain was 0.70. This reflects the success of the learning method in encouraging students to think critically and develop hypotheses based on the data they observe and their analysis. This increase is in line with the findings (Chen et al., 2024) which emphasizes the importance of discovery-based learning in improving students' scientific thinking skills. A hypothesis is a critical step in the scientific process that helps students develop analytical and critical thinking skills. Findings (Firmansyah & Hasan Subekti, 2023) emphasizes that discovery-based learning provided with sufficient guidance can significantly improve students' ability to formulate appropriate hypotheses, which is consistent with the results of this research.

However, there are also aspects that show a lower increase, such as prediction skills which only increased by 15% from the first meeting to the third meeting with an N-gain of only 0.45. This may indicate that students need more practice or guidance in developing the ability to predict outcomes based on the data they collect. Research by Nasution & Fadilah (2024) showed that high cognitive load without sufficient guidance can hinder students' ability to make accurate predictions. Therefore, an important suggestion is to provide more scaffolding or support in the prediction stage to ensure students can develop these skills better. Although still significant, this may indicate that the learning methods or approaches used need to be further optimized to facilitate students in developing this ability more effectively. In this context, the use of real contexts and providing feedback oriented towards improving science process skills can support better results (Duncan et al., 2021).

A fairly high increase was also seen in the communicating aspect with an N-gain of 0.68. This shows that students become more capable of conveying their findings and observations effectively, which is an important skill in science. The ability to communicate results clearly and precisely is very important in the science process and discovery learning-based teaching appears to be effective in improving this ability. Research (Ren & Zhao, 2023) shows that audio-visual and interactive media can help students develop better communication skills, which supports these findings.

In environmental literacy, the resulting N-gain value shows quite a good increase in both domains after implementing discovery learning-based LKPD (Tabel 5).

Tabel 5. Ecological literacy result

Domains	Learning subjects	Score (%)		N-gain
		Pre-test	Post-test	
Ecological knowledge	The condition of the surrounding environment	59	71	0.29
	Environmental pollution	55	67	0.27
	Environmental problem-solving	62	76	0.36
	Average	59	71	0.31
Cognitive ability	Identify environmental issues	60	84	0.60
	Analysing environmental issues	56	68	0.28
	Resolving environmental issues	52	64	0.26
Average		56	72	0.38
Total average		57	72	0.35

In the ecological knowledge category, an N-gain of 0.31 indicates that students experience an increased understanding of the state of the surrounding environment, environmental pollution, and solving environmental problems after learning. This is in accordance with research by Lachner et al. (2022) which states that discovery learning is effective in increasing understanding of scientific concepts.

In the cognitive ability category, an N-gain value of 0.38 indicates a more significant increase in analytical and planning abilities to solve environmental problems. This increase can be attributed to the findings of

(Lachner et al., 2022; Logan et al., 2021), which indicates that a guided discovery learning approach can improve students' analytical, and problem solving abilities. The total average increase of 0.35 shows that overall, the implementation of discovery learning-based LKPD has a significant positive impact on students' ecological literacy. However, some research, such as that conducted by Nismidawati et al. (2022), shows that the success of this method is highly dependent on proper implementation and support from teachers, suggesting that more effective implementation could result in higher improvements.

Based on data (Tabel 5), a moderate effect size (d) value was obtained for both domains. Thus, the effect size of environmental literacy is 0.47 in the medium category. This effect size shows that the implementation of discovery learning-based LKPD has a positive impact on increasing students' ecological literacy and cognitive abilities. It indicates that the implemented intervention is having a positive effect.

Evaluation

Formative and summative evaluation methods are employed. Formative evaluation is conducted at each stage of the ADDIE model. Formative evaluation is conducted at the analysis stage, including curriculum analysis, student analysis, and material analysis, with the objective of adapting the LKPD product to its eventual appearance. The evaluation at the design stage entails adjustments to the product under development, with the objective of aligning it with the indicators of the discovery learning model, science process skills, and environmental literacy. At the development stage, evaluation entails implementing improvements in accordance with the recommendations provided by the validator.

The evaluation at the implementation stage is conducted by examining the challenges encountered by students during the trial period in the classroom setting. Subsequent to the conclusion of each developmental stage, a summative evaluation is conducted. This final stage evaluation assesses the discovery learning-based LKPD product following its testing and validation. The success of the LKPD development process is gauged by the feedback and responses of students who have completed the questionnaire. The questionnaire employed encompasses a range of assessment criteria, including interest, design, and the presentation of the material or contents of the LKPD. The analysis of student responses revealed that the category was deemed highly practical. This indicates that the LKPD, which is based on discovery learning regarding Indonesian ecology and biodiversity, is a highly practical tool for learning, as it effectively enhances the science process skills and environmental literacy of students at SMP Negeri 2 Bungku.

Conclusion

The results validated this development, with an 88% score that was further verified by the teacher response score, which fell within the "very practical" category. The product of this development has a positive effect on students' science process skills, with an N-gain of 0.60 in the moderate category, indicating a significant improvement. The effect size of 0.47 in the moderate category indicates that this improvement is highly significant. Furthermore, the development results had a significant impact on students' environmental literacy, with an N-gain of 0.35 in the medium category. The effect size of environmental literacy was 0.47 in the medium category. It can finally be stated that discovery learning-based LKPD represents an effective learning tool for the enhancement of science process skills and environmental literacy among seventh-grade students at SMP Negeri 2 Bungku.

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Author Contributions

Conceptualization, S. A. A. M.; methodology, S. A. A. M., N. D. N.; validation, M. P., and I. K. W. formal analysis, S. A. A. M. and M.; investigation, S. A. A. M.; resources, S. A. A. M. and N. D. N.; data curation, S. A. A. M.; writing—original draft preparation, S. A. A. M.; writing—review and editing, N. D. N. and M.; visualization, S. A. A. M.; supervision, M.; project administration, S. A. A. M., M., N. D. N.; funding acquisition, S. A. A. M.

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Conflicts of Interest

The authors declare no conflict of interest.

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