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Perceived understanding of students on the role of vaccines in the immune system: A study in the context of biological education

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Abstract

This study explored the perceived understanding of Senior High School students in Zambales regarding the role of vaccines in the immune system, with particular attention to the influence of biological education and the prevalence of misconceptions. Using a descriptive quantitative research design, forty-eight (48) students participated through convenience sampling. Data collection was conducted using a structured questionnaire, and results were analyzed through basic statistical tools such as frequency, percentage, mean, and thematic analysis. Findings revealed that while a majority of students rated their understanding as "Good," misconceptions were widespread, particularly the beliefs that vaccines directly kill viruses and that vaccines serve as immediate cures. Students who had formal biology instruction scored higher in perceived understanding compared to those without prior exposure. Despite positive perceptions, the persistence of misconceptions emphasized the need for more interactive, critical-thinking-centered educational approaches. The study contributes to the broader discourse on science education by highlighting gaps between perceived and actual understanding and proposing instructional strategies to enhance vaccine literacy. Recommendations include the integration of simulation activities, real-world case discussions, and partnerships with healthcare professionals to reinforce accurate scientific knowledge.

Keywords: Biological Education; Immune System; Misconceptions; Science Education; Senior High School Students; Vaccine Literacy; Zambales

1. Introduction

Vaccines are a cornerstone of public health, effectively reducing morbidity and mortality by stimulating an immune response without causing disease (Flannery et al., 2018). They have substantially decreased hospitalizations and deaths related to various infectious diseases, such as influenza and pneumococcal disease (Wahl et al., 2018). The COVID-19 pandemic has underscored the importance of vaccine literacy, which is essential for fostering public confidence and countering misinformation (Dong et al., 2020). Effective communication and educational interventions are critical for improving the understanding of vaccine benefits and addressing hesitancy, particularly among vulnerable populations (Nyalundja et al., 2024). In addition to reducing the burden of disease through herd immunity, vaccines can facilitate equitable access to health services when integrated into comprehensive public health strategies (Owino et al., 2023).

Integrating immune literacy into early biological sciences education is critical to dispel misconceptions regarding vaccine function. Studies indicate that many healthcare professional students hold flawed views such as vaccines directly "killing" pathogens or being unnecessary after disease control, demonstrating variability in baseline content knowledge (Dybsand et al., 2019). Lee and Tran (2023) emphasize that improved curriculum design, which incorporates scientific argumentation and multidisciplinary strategies, can enhance students' understanding of immunological processes and vaccine efficacy. Moreover, the inclusion of targeted modules addressing vaccine

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hesitancy has been shown to increase both confidence and competency in addressing public concerns (Rusgis et al., 2022; Cruz 2023). These findings suggest that pedagogical reforms—emphasizing simulation, dialogue-based learning, and clear scientific communication—are essential for counteracting misinformation, ultimately equipping future healthcare providers with the skills needed to combat vaccine hesitancy effectively (Dybsand et al., 2019; Rusgis et al., 2022).

In rural areas in the Philippines such as Zambales, vaccine education is challenged by limited access to scientific information, disparities in educational quality, and strong cultural influences on health behavior (Reyes et al., 2023). Despite efforts under the K-12 curriculum, uneven understanding of immunological concepts persists, partly because resource limitations and inconsistent teaching standards impede the delivery of comprehensive scientific content (Reyes et al., 2023). Moreover, cultural norms and local beliefs further complicate the acceptance and proper understanding of vaccines, reflecting a general trend where lower educational attainment correlates with reduced vaccine literacy (Montuori et al., 2023). Intersectoral strategies that involve local health centers, community leaders, and educational institutions are imperative to tailor messaging and bridge these gaps, ensuring that public health initiatives align with local socioeconomic realities (Carter et al., 2022; Yu & Santos, 2025).

Constructivist Learning Theory posits that learners construct knowledge through interactions with their environment, with meaning emerging from the integration of prior experiences, formal instruction, and societal narratives (Versteeg et al., 2018). In biological education, this theoretical framework supports the notion that students' understanding of vaccines is not solely derived from lecture-based content but is also shaped by peer interactions and active engagement in problem solving. Versteeg et al. (2018) emphasize that peer instruction and collaborative activities allow learners to confront and reconstruct misconceptions about vaccine mechanisms, providing a deeper comprehension of immunological concepts. Furthermore, the shift towards active learning environments in postsecondary biology illustrates how constructivist strategies promote interactivity and encourage students to explore and question established narratives (Driessen et al., 2020). Consequently, integrating these methodologies into vaccine education can bridge the gap between formal curriculum and personal interpretations, thereby enhancing overall scientific literacy and mitigating vaccine hesitancy.

Given these considerations, a research gap persists regarding how well senior high school students, particularly in provincial areas like Zambales, perceive and understand the role of vaccines in the immune system. While national studies on vaccine literacy exist, localized investigations focusing on students' perceived understanding and educational influences are still limited. Understanding students' perceptions is critical because it can directly impact their future health decisions and attitudes towards public health programs. Moreover, insights from this study can inform improvements in biology teaching strategies, contributing to more effective science education and ultimately fostering a scientifically literate citizenry.

Thus, this research aimed to determine the perceived understanding of Senior High School (SHS) students in Zambales regarding vaccines and their function in the immune system, to identify prevalent misconceptions among students about vaccines, to analyze the influence of biological education on students' vaccine literacy, and to recommend strategies for improving vaccine education within the SHS biology curriculum.

2. Methodology

This study employed a descriptive quantitative research design to assess the perceived understanding of Senior High School (SHS) students in Zambales regarding the role of vaccines in the immune system. Descriptive research was chosen because it is appropriate for gathering information about participants' perceptions and levels of understanding without manipulating any variables. The respondents of the study were forty-eight (48) SHS students selected through convenience sampling, as they were the most readily available and willing participants at the time of data collection.

The primary instrument used was a researcher-made survey questionnaire composed of three parts: the first part gathered basic demographic information such as age, sex, and academic strand; the second part measured the students' perceived understanding of vaccines and their role in the immune system using a 4-point Likert scale ranging from "Poor" to "Excellent"; and the third part included an open-ended question designed to uncover specific misconceptions or personal beliefs regarding vaccines.

Prior to administration, the questionnaire was validated by two biology teachers to ensure the clarity and appropriateness of the questions. Data collection was conducted face-to-face in a controlled setting within the school premises, with participants being briefed on the study's purpose, their voluntary participation, and the confidentiality of their responses.

Data were analyzed using basic descriptive statistics such as frequency, percentage, mean, and standard deviation to interpret the levels of perceived understanding and to identify patterns in students' responses. Responses to the open-ended question were analyzed through thematic coding to categorize common misconceptions and ideas about vaccines. Ethical considerations such as informed consent, confidentiality, and the right to withdraw from the study at any point were strictly observed throughout the research process.

3. Results and discussion

3.1. Demographic Profile of the Respondents

The study involved a total of forty-eight (48) Senior High School students from Zambales. Out of these respondents, 27 students (56.25%) were female, and 21 students (43.75%) were male. In terms of academic strand, 28 students (58.33%) were from the Science, Technology, Engineering, and Mathematics (STEM) strand, while 20 students (41.67%) were enrolled in Humanities and Social Sciences (HUMSS) and other strands. The majority of the respondents were aged between 16 and 18 years old.

The demographic data reveal a fairly balanced representation of male and female students, with a slight predominance of females. STEM students comprised the larger portion of the participants, which may suggest a greater exposure to science-related concepts compared to those from non-science strands. The typical age range of respondents also ensures that the participants are at an appropriate stage of cognitive development to comprehend scientific concepts such as vaccination.

Understanding the demographic background is important because gender, academic strand, and age can influence students' access to scientific knowledge and their ability to interpret information about vaccines. STEM students, for instance, may have had more exposure to biological concepts compared to students from other strands, potentially affecting their perceived understanding. Recognizing these demographic characteristics provides valuable context for interpreting subsequent findings on knowledge and misconceptions about vaccines.

3.2. Perceived Understanding of Vaccines and the Immune System

In terms of perceived understanding, 27 students (56.25%) rated their knowledge of vaccines and the immune system as "Good," while 8 students (16.67%) rated theirs as "Excellent." Meanwhile, 10 students (20.83%) believed their understanding was only "Fair," and 3 students (6.25%) rated their knowledge as "Poor." The overall mean score recorded for perceived understanding was 2.83 on a 4-point Likert scale, which corresponds to a "Good" level of understanding.

The results suggest that a significant majority of the respondents had a favorable self-assessment regarding their understanding of vaccines. More than half perceived themselves as having a good grasp of the topic, while only a small proportion considered their knowledge poor. The relatively high mean score reflects a generally positive perception among the students toward their scientific literacy concerning vaccines.

Although students reported moderate to good levels of perceived understanding, this self-assessment does not necessarily equate to factual accuracy. It is possible that overconfidence or limited depth of knowledge may have influenced their self-ratings. Therefore, while the findings are encouraging, further scrutiny is needed to determine whether this perceived understanding aligns with scientifically accurate concepts.

3.3. Common Misconceptions about Vaccines

An analysis of the open-ended responses revealed that 18 students (37.5%) believed that vaccines directly kill viruses. Additionally, 12 students (25.0%) expressed the belief that vaccines are unnecessary for strong and healthy individuals, and 10 students (20.8%) thought vaccines serve as immediate cures for infections. A smaller percentage, approximately 16.7%, held other misconceptions, such as the belief that vaccines work instantly after injection.

The presence of these misconceptions among a significant portion of the respondents indicates that while students may feel confident about their knowledge, there remain critical misunderstandings about the basic principles of immunology. The most common error—the belief that vaccines kill viruses directly—suggests a need for more detailed education about how vaccines stimulate immune memory rather than directly attacking pathogens.

These findings highlight the need for biology teachers and educational programs to focus not only on promoting general awareness of vaccines but also on correcting specific misunderstandings. Addressing these misconceptions is crucial for developing scientifically literate individuals who can make informed health decisions in the future.

3.4. Influence of Biological Education on Perceived Understanding

Out of the 48 students, 35 students (72.92%) indicated that they had encountered lessons on the immune system and vaccines during their biology classes, while 13 students (27.08%) had not. Those who had been exposed to such lessons reported a higher mean perceived understanding score of 3.02, while those without formal instruction had a lower mean score of 2.38.

The data show a clear positive correlation between exposure to biological education and higher perceived understanding scores. Students who had lessons on the immune system were more likely to rate their knowledge as "Good" or "Excellent" compared to their peers who had not encountered formal instruction on the topic. This suggests that structured classroom learning significantly enhances students' confidence in their scientific knowledge.

The impact of biology education in improving vaccine literacy cannot be overstated. Structured lessons provide students with the correct scientific framework for understanding vaccination, reducing susceptibility to misinformation. However, the persistence of misconceptions among even those who had formal education suggests that lessons need to be more comprehensive, contextualized, and interactive.

3.5. Plan Based on Findings

Based on the findings, it is proposed that improvements be made in the delivery of biology education concerning vaccines and the immune system. It is recommended to integrate interactive strategies such as animated visualizations of immune responses, real-life case studies of vaccine-preventable diseases, and classroom discussions that directly address common misconceptions identified in this study. Furthermore, inviting healthcare professionals to schools for vaccine education seminars can reinforce scientifically accurate information.

The analysis of results indicates that although biological education positively influences perceived understanding, it does not fully eliminate misinformation. Students would benefit from instructional approaches that not only present facts but also challenge and correct misunderstandings actively. Emphasizing critical thinking and real-world applications in teaching could help bridge the gap between perceived knowledge and scientific accuracy.

Addressing misconceptions early through school-based interventions can contribute significantly to public health in the long run. A well-informed youth population is more likely to support vaccination programs and resist vaccine misinformation, leading to higher community immunity levels and better preparedness against future public health crises.

4. Conclusion

This study investigated the perceived understanding of Senior High School students in Zambales regarding the role of vaccines in the immune system, focusing on how biological education influences their knowledge and identifying prevalent misconceptions. Through a descriptive quantitative approach involving forty-eight respondents, it was revealed that the majority of students rated their understanding of vaccines as "Good," with a mean perceived understanding score of 2.83. However, despite this generally positive self-assessment, a significant number of misconceptions persisted, notably the beliefs that vaccines directly kill viruses, that they are unnecessary for strong individuals, and that vaccines serve as immediate cures. Students who had been formally exposed to biology lessons on immunology reported higher perceived understanding scores compared to those who had not, emphasizing the critical role of structured education in shaping scientific literacy.

The findings affirm that while biological education improves students' confidence in their vaccine knowledge, it does not fully eliminate gaps in scientific understanding. The results contribute to the existing body of knowledge by demonstrating the complex relationship between perceived knowledge and actual conceptual accuracy, particularly in the context of rural education settings like Zambales. The study highlights the urgent need to enhance science education strategies, particularly by incorporating interactive and critical thinking-based methods, to ensure that students not only feel knowledgeable but truly comprehend how vaccines function as a preventive measure against infectious diseases.

In light of these findings, it is recommended that biology curricula be updated to include more engaging, practical, and misconception-correcting strategies. Schools should integrate activities such as visual simulations of the immune response, real-world case discussions about vaccine-preventable diseases, and opportunities to engage with healthcare professionals. Future research may explore a larger and more diverse sample to validate these findings across different regions or evaluate the effectiveness of specific educational interventions aimed at correcting misconceptions. Additionally, longitudinal studies could assess whether improved biology education has lasting effects on students' public health behavior, such as vaccine uptake and advocacy. By continuously refining educational approaches based on empirical evidence, educators can contribute significantly to building a scientifically literate and health-conscious generation.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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