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The impact of information sources on COVID-19 vaccination intentions among pre-service life sciences teachers in South Africa: A cross-sectional study

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Abstract

Introduction: The COVID-19 pandemic underscored the importance of health literacy, where pre-service Life Sciences teachers can promote safe behavioral practices such as vaccination. However, the health information sources influencing their behavioral intentions toward vaccination are poorly understood. This study examines how different sources impact vaccination attitudes and behaviors among pre-service Life Sciences teachers.

Methods: A cross-sectional study was conducted involving pre-service Life Sciences teachers (n = 87) from a South African university. Data were collected using a closed-ended questionnaire to explore the types of information sources they use and how these sources influence their attitudes, subjective norms, and perceived behavioral control related to COVID-19 vaccination.

Results: Participants utilized a diverse array of information sources, including government communiques, traditional media, social media, research publications, and personal interactions. Although the susceptibility to misinformation from unreliable sources such as social media was identified, participants' scientific training served as a buffer against such misinformation. Notably, the type of information source did not significantly predict subjective norms and perceived behavioral control. However, information sources significantly influenced attitudes and normative beliefs toward vaccination.

Discussion: The study underscores the complex relationship between information sources, cognitive processes, and behavioral intentions in the context of health literacy among pre-service Life Sciences teachers. The findings suggest that while their scientific background provides a defense against misinformation, targeted strategies are essential to ensure the reliability and validity of information. Further research is warranted to understand additional factors influencing this demographic's vaccination intentions and to inform more effective health literacy initiatives. This research bears significant implications for public health communication strategies, particularly in a pandemic.

Take home message: This study highlights pre-service Life Sciences teachers' pivotal role in fostering health literacy, particularly regarding COVID-19 vaccination. While their scientific training aids in discerning valid information, the study emphasizes the need to ensure accuracy in frequently used information sources to optimize their impact on public health.

Keywords: Behavioral Intentions; COVID-19 vaccination; health literacy; information sources; pre-service life sciences teachers.

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INTRODUCTION

The spread of communicable diseases, such as COVID-19, caused by the SARS-COV-2 coronavirus, is influenced by many factors, including educational, economic, socio-cultural, and behavioral aspects [1,2]. Given this complexity, coordinated educational and multidisciplinary efforts are vital to mitigating the spread of such diseases. In response to the COVID-19 pandemic, countries worldwide, including South Africa, adopted various strategies to educate the public and dispel myths and misinformation, such as the erroneous association of COVID-19 with 5G technology [3]. The South African Ministry of Health employed an array of media platforms, including television, radio, social media, SMS, and physical media like leaflets and banners, to promote protective measures like handwashing, mask-wearing, and social distancing [3].

Despite the extensive use of social media during the pandemic, its reliability as a source of information has been questioned. Social media often circulates unverified content, leading to an "infodemic" characterized by misinformation and conspiracy theories [4-6]. Recognizing these risks, health authorities have emphasized the importance of disseminating scientifically valid information through academic and official government channels, which have shown to be more trusted and effective in promoting compliance with health guidelines [7,8].

The role of science teachers, particularly in science and health education, is critical in this context. Science teachers are trusted figures who can significantly influence student behavior through direct interaction and curriculum integration, enhancing health and science literacy [1,2,9]. Despite recognizing the potential role of science teachers in health education, there is a noted disparity in their attitudes towards educational initiatives and health measures like vaccination. During the pandemic, studies reported considerable vaccine hesitancy among teachers attributed to various factors, including misinformation, vaccine safety concerns, and chronic health conditions, suggesting that teachers' skepticism towards vaccines was often greater than that of their students [10-13].

This hesitancy is not isolated to teachers alone but is part of a broader public health challenge. Vaccine hesitancy, as defined by the WHO, can be influenced by distrust in healthcare providers or vaccines, complacency, or access barriers, and ranges from cautious acceptance to outright rejection [13-16]. Understanding these nuances among teachers is essential, given their influential role in shaping societal norms and behaviors toward health practices [15,16].

Efforts to mitigate COVID-19 have emphasized the necessity of reliable information and the harmful potential of misinformation [A]. As teachers frequently engage with influential platforms and can impact public perceptions significantly, enhancing their health literacy is crucial. This approach ensures they are not just health information recipients but active scientific knowledge disseminators, thereby playing a pivotal role in public health initiatives [17-19]. The varied responses to vaccines among teachers across different regions highlight the need for targeted research to understand and

address the specific concerns and misconceptions within the teaching community, ensuring they can effectively contribute to health education and promotion [20-23].

Aim and research question

Considering the above discourse, the current research aimed to determine the relationship between reliance on different sources of information and behavioral intentions towards COVID-19 vaccination among South African pre-service Life Sciences teachers as a preliminary effort to understand teachers' role in promoting health literacy and safe behavioral practices. The research question framing the current research was: "*What is the relationship between reliance on different sources of information about COVID-19 and behavioral intentions towards vaccination among South African pre-service Life Sciences teachers*?"

Our research focused on pre-service sciences teachers from a South African university because South Africa reported the highest COVID-19 cases in Africa despite implementing several efforts to prevent the disease's spread [24]. According to the National Institute for Communicable Diseases [25], more than 3.6 million cases were reported in South Africa. These statistics necessitate a thorough investigation of the mechanisms causing the spread of COVID-19 in South Africa. Likewise, ways to combat the future spread of communicable diseases must be investigated.

Theoretical framework

This study utilizes the Theory of Planned Behavior (TPB) (Figure 1) to explore health-related behaviors, particularly the intentions behind COVID-19 vaccination [26-30]. This theory posits that behavioral intentions, which reflect a person's readiness to engage in a behavior, are shaped by motivational factors, subjective norms, and perceived behavioral control [31,32]. Subjective norms refer to the perceived pressures from significant others to perform or not perform the behavior. In contrast, perceived behavioral control relates to the individual's beliefs about their capabilities to perform the behavior under various circumstances [32-34]. This framework suggests that actions are influenced by a willingness to attempt a behavior and the resources and opportunities available. Additionally, Ajzen [31] highlights that attitudes towards behaviors, the influence of others' expectations, and control beliefs are interlinked and collectively impact behavioral intentions and actions, making this theory a robust tool for analyzing responses to health interventions like vaccinations.

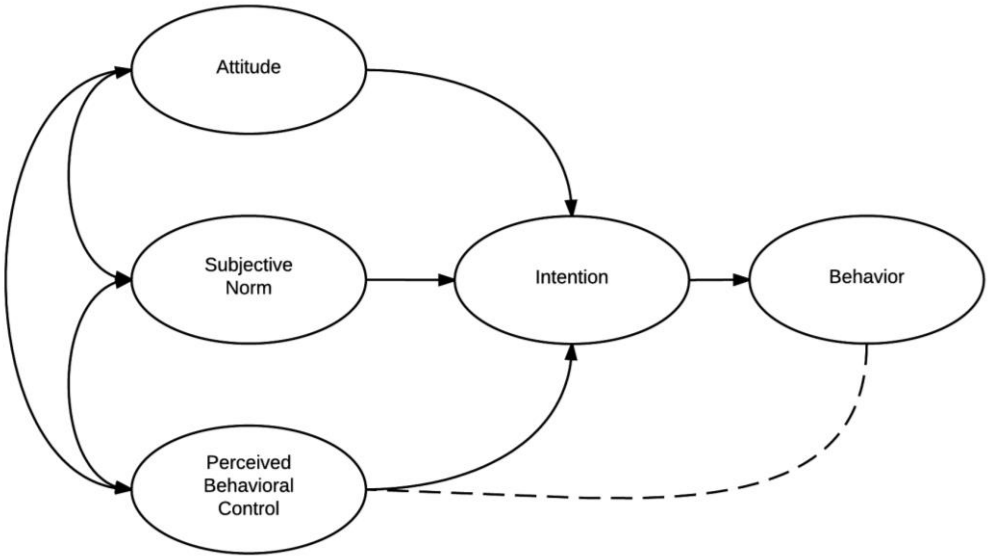

Figure 1. The theory of planned behavior (Ajzen, 1991).

The TPB is relevant and significant for this study as it provides a comprehensive framework to understand the determinants of vaccination intentions among pre-service Life Sciences teachers. By

focusing on behavioral intentions, subjective norms, and perceived behavioral control, TPB helps dissect the complex psychological and social dynamics influencing teachers' decisions regarding COVID-19 vaccination [31,32]. This approach allows the study to identify specific factors that could be targeted to enhance vaccine uptake, which is crucial for formulating effective health communication strategies and educational interventions in response to public health crises.

METHODS

The adopted methodology, deeply rooted in the positivist paradigm, prioritized the objectivity of data, the neutrality of the observer, and the identification of relevant variables along with their interrelationships. This approach permitted a quantitative treatment of variables based on established models. It also utilized a blend of inductive and deductive reasoning to support the validity of the inferences drawn, extrapolations made, and generalizations proposed.

Study context and sampling

Participants were from a single purposively selected university in South Africa, with a total final year class of about 365 Bachelor of Education (BEd) students majoring in Life Sciences didactics where scientific knowledge of viruses and vaccines is taught. Based on this, we estimated, using Taherdoost's [34] formula ($n = [p(100-p)z^2]/E^2$ for estimating the minimum sample size), that 76 participants would give a confidence level of 95 percent, with a margin of error of 10 percent, which is typically acceptable in social sciences [35]. As Bartlett et al [36] recommended, we used 50% to estimate *p* because this will maximize variance and result in the largest sample size. This led us to conclude that a sample size of over 76 individuals would be appropriate. We chose participants from one university because of its accessibility and convenience. Furthermore, the university trains the largest number of teachers in South Africa through distance education. These teachers are based across the country, thus providing a glimpse into factors affecting teachers in South Africa.

In the end, eighty-seven (n = 87) final-year Bachelor of Education pre-service Life Sciences teachers were selected to participate in the study. As part of their training, they were exposed to scientific knowledge related to viruses, vaccines, and communicable diseases. Participants also studied cell biology, cytogenetics and embryology, and animal physiology, which could further enhance their understanding of COVID-19 as a disease caused by the virus. They also studied research methodology and educational studies. Data were collected in the final two months of the academic year when the participants would have graduated. All participants who participated in the study did so voluntarily. The research was approved by the ethics committees of the University of South Africa (Ref 2021 RPSC 088, and Ref 2021/09/08/90291786/34/AM).

Instrument description and data collection

The first part of the questionnaire sought to determine the extent to which the participants relied on the different sources of information (Table 1) to learn about COVID-19. We sought literature to identify the most utilized sources of information about COVID-19 [4,6-8]. Therefore, participants were asked to rank these sources in the order they relied on them to learn about COVID-19. The second part of the questionnaire probed the participants' behavioral intentions toward COVID-19 vaccination using the theory of planned behavior (Figure 1) [31,32] as a framework. Consequently, 25 closed-ended Likert scale items were used to measure attitudes, subjective norms, perceived behavioral control, behavioral beliefs, and normative beliefs toward the COVID-19 vaccination (Table 2). These items were designed per the guidelines recommended by Ajzen [30]. Five items were used for each of these constructs, in line with Ajzen [31], who suggests that "five to six items are formulated to assess each of the theory's major constructs."

Table 1. Sources of information about COVID-19.

Source of information	Definition
Social media	• Websites and applications that enable users to create and share content or to participate in social networking. They included Twitter, YouTube, Instagram, Snapchat, WhatsApp, and Reddit, along with their Chinese

	equivalents, WeChat, Weibo, Tencent, TikTok, and Toutiao. This excluded posts by close friends, family, and the government.
Newspapers	• *Digital and print materials containing news, opinion articles, features, and advertising are distributed periodically*. This excluded government communication and social media posts unless they led to a newspaper website. Examples include the Mail & Guardian, Daily Maverick, the Sunday Times, News24, the Sowetan, Pretoria News, and Isolezwe.
Radio	• Sound communication by radio waves, usually through the transmission of music, news, and other programs from single broadcast stations to multitudes of individual listeners equipped with radio receivers. This excluded government communication. Examples included Metro FM, SA FM, Power FM, Ukhozi FM, Umhlobo Wenene FM, and Radio 702.
Television	• Visual communication channels for transmitting music, news, and other programs from single broadcast stations to multitudes of individual listeners equipped with radio receivers. This excluded government communication. Examples included SABC TV, Multichoice channels, and eTV channels.
Research publications	• Peer-reviewed oral (i.e., conference), digital, or scientific print work produced by qualified scientists, excluding government communication.
Textbooks	• Digital or print books containing a comprehensive compilation of content knowledge in a branch of study to educate about it.
Family	• A group of two or more persons related by birth, marriage, or adoption
Friend	• A person with whom one has a bond of mutual affection. A friend was defined as someone with whom the participant has direct contact outside social media.
Government communique	• The activities of public sector institutions and organizations aimed at conveying and sharing information. Such communication could be through newspapers, radio, television, and social media. These could be from government departments, ministers, and identified government officials.

The instrument's reliability (i.e., the items probing the participants' behavioral intentions toward COVID-19 vaccination) was measured using Cronbach's alpha coefficient to quantify the extent to which items in the questionnaire consistently measure the same construct. Cronbach's alpha was calculated based on the responses to items measuring various factors, such as the extent to which the participants relied on the different sources of information and the attitudes, subjective norms, perceived behavioral control, behavioral beliefs, and normative beliefs towards COVID-19 vaccination. To this end, results showed a Cronbach's alpha coefficient of .894, implying reasonable internal consistency. The average inter-item correlation was also calculated to determine the scale's reliability. The purpose of using the average inter-item correlation is to understand the extent to which the items are related to one another or how consistently they measure the same construct [37]. As a guideline, an average inter-item correlation of .15 to .50 reflects an acceptable internal consistency range [38]. In the current research, the average inter-item correlation on items probing the extent to which the participants relied on the different sources of information was .404, which falls within the acceptable internal consistency range.

Table 2. Examples of items used to probe participants' attitudes, subjective norms, perceived behavioral control, behavioral beliefs, and normative beliefs toward the COVID-19 vaccination.

Construct	**Example of items used in the questionnaire**
Attitudes	On a scale of 1 to 5, do you think COVID-19 vaccines are good or bad for you?
	In your opinion, is getting vaccinated against COVID-19 beneficial?

Subjective norms	On a scale of 1 to 5, do you think most people who are important to you (e.g., family, friends, colleagues) approve of COVID-19 vaccines?
	On a scale of 1 to 5, how much do you perceive that people who are important to you (e.g., family, friends, colleagues) think you should get vaccinated against COVID-19?
Perceived behavioral control	On a scale of 1 to 5, how confident are you that you have enough information to make an informed decision about getting the COVID-19 vaccine?
	How confident are you that you can overcome any challenges or difficulties you might encounter in the process of getting vaccinated against COVID-19?
Behavioral beliefs	Do you believe that getting vaccinated against COVID-19 is beneficial for you?
	Do you think getting vaccinated against COVID-19 will help protect your loved ones and the wider community?
Normative beliefs	On a scale of 1 to 5, how much do you perceive that people who are important (e.g., family, friends, colleagues) believe that getting vaccinated against COVID-19 is beneficial for you?
	On a scale of 1 to 5, how much do you perceive that people who are important to you (e.g., family, friends, colleagues) believe that everyone should get vaccinated against COVID-19?

The entire instrument was piloted and validated using a subset of students with the same characteristics as the target population. The main objective of this pilot was to enhance the instrument's face, content, and criterion-related validity. Furthermore, a group of nine specialists, including two education experts holding PhDs, two science education experts with PhDs, an English language expert with a master's degree in English, two pre-service science teachers, and two in-service science teachers, evaluated the tool against the research objectives and verified its authenticity. The assessment conducted by these experts and the pilot group aimed to establish the instrument's face, content, and criterion-related validity, as defined by Taherdoost [39]. Face validity was ensured by confirming the relevance of the survey questions to the research topic and ensuring participants' comprehension of the questions to provide meaningful responses. Content validity was maintained by guaranteeing that the survey questions covered all relevant aspects of participants' behavioral intentions toward adopting COVID-19 preventative measures. Criterion-related validity involved examining whether the survey responses accurately predicted the future health behaviors of pre-service science teachers, such as their willingness to adopt preventative measures for COVID-19. The assurance of face, content, and criterion-related validity for the instruments employed in this research is crucial to ensure the accuracy and dependability of the collected data. The reports from the pilot group and the panel of experts confirmed the instrument's validity.

Data analysis

The dataset, which encapsulates the degree of reliance participants placed on various information sources, underwent descriptive analysis. We processed ratio data to derive frequency distributions via SPSS. We employed Spearman's Rho to examine the correlation among the different sources of information that participants utilized to learn about COVID-19. This method was chosen because the data were ordinal.

Regarding measuring behavioral intentions toward COVID-19 vaccination, we relied on Ajzen's [31] argument that behavioral beliefs form attitudes, normative beliefs shape perceived social pressure, and control beliefs instill a sense of self-efficacy. The influence of attitudes and social pressure on intent is moderated by perceived control. Generally, positive attitudes and norms and strong perceived control foster a strong intention to perform a behavior. Assuming adequate actual control, individuals are likely to act on their intentions when opportunities present themselves. Hence, intention is

considered the immediate precursor to behavior. Consequently, we aggregated the responses to each item within the constructs as indicative of the construct as either favorable or unfavorable. We then explored the relationship between the constructs in line with the suggestion that "the more favorable the attitude and subjective norm, and the greater the perceived control, the stronger should be the person's intention to perform the behavior in question." We employed Spearman's rho to measure the association between variables in the study, given that the data were ordinal.

The regression analysis was used to determine the relationship between attitudes, behavioral beliefs, and normative beliefs toward COVID-19 vaccination and reliance on information sources. This analysis allowed for modeling the association and quantifying the strength of this relationship, considering other potential factors that might influence attitudes. Using regression, we could identify which information sources significantly impact vaccination attitudes, behavioral beliefs, and normative beliefs, providing valuable insights for public health interventions and communication strategies. These measurement techniques were chosen because they are appropriate for ordinal scale data and robust against normality assumption violations.

RESULTS

Reliance on a different source of information regarding COVID-19

Data were analyzed to determine the extent to which pre-service teachers rely on the different sources of information to learn about COVID-19. Results (Figure 2) showed that 89% of the participants relied on government communique, while 83% relied on television. Less than 50% of the participants relied on newspapers. Social media was selected by 80% of the participants as a source of information they relied on.

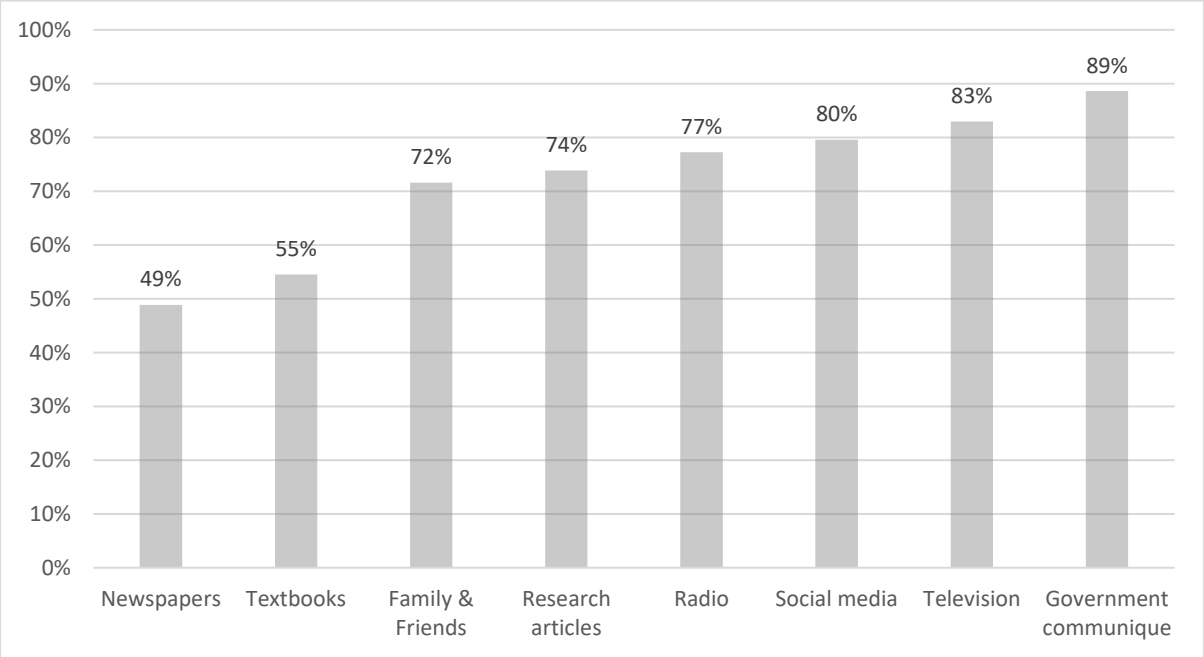

Figure 2. The participants' reliance on different sources of information.

While results showed a significant correlation between all the sources of information, it emerged that there is no significant correlation between reliance on social media and research publications (Table 3). This suggests that the respondents who rely on social media do not rely on research publications. We also observed a significant but weaker correlation (significant at the 0.05 level (2-tailed)) between reliance on social media and reliance on community radio, reliance on social media and reliance on family and friends, reliance on research publications and reliance on family and friends, as well as reliance on textbooks and reliance on government communique. The strongest correlation was between reliance on television and reliance on government communique.

Table 3. Non-parametric (Spearman's Rho) correlation between reliance on different sources of information among the participants

	1	2	3	4	5	6	7
1. Newspapers							
2. Radio	.508**						
3. Television	.351**	.449**					
4. Science research articles	.318**	.486**	.371**				
5. Textbooks	.562**	.449**	.341**	.432**			
6. Friends and family	.308**	.577**	.382**	.307**	.310**		
7. Government announcements	.380**	.523**	.596**	.347**	.277**	.544**	
8. Social media	.316**	.261*	.439**	.230*	.398**	.263*	.362**

Note: **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Behavioral intentions toward vaccination

Concerning behavioral intentions, results showed that most participants reported safe behavioral intentions, including attitudes, subjective norms, perceived behavioral control, behavioral beliefs, and normative beliefs (Figure 3). Despite this observation, it was found that 26% (n = 22) of the participants reported negative perceived behavioral control, 22% (n = 19) reported negative attitudes toward vaccination, and 20% (n = 17) reported negative behavioral beliefs. It was also observed that 19% (n = 16) to 26% (n = 22) of the participants reported neutral behavioral intentions.

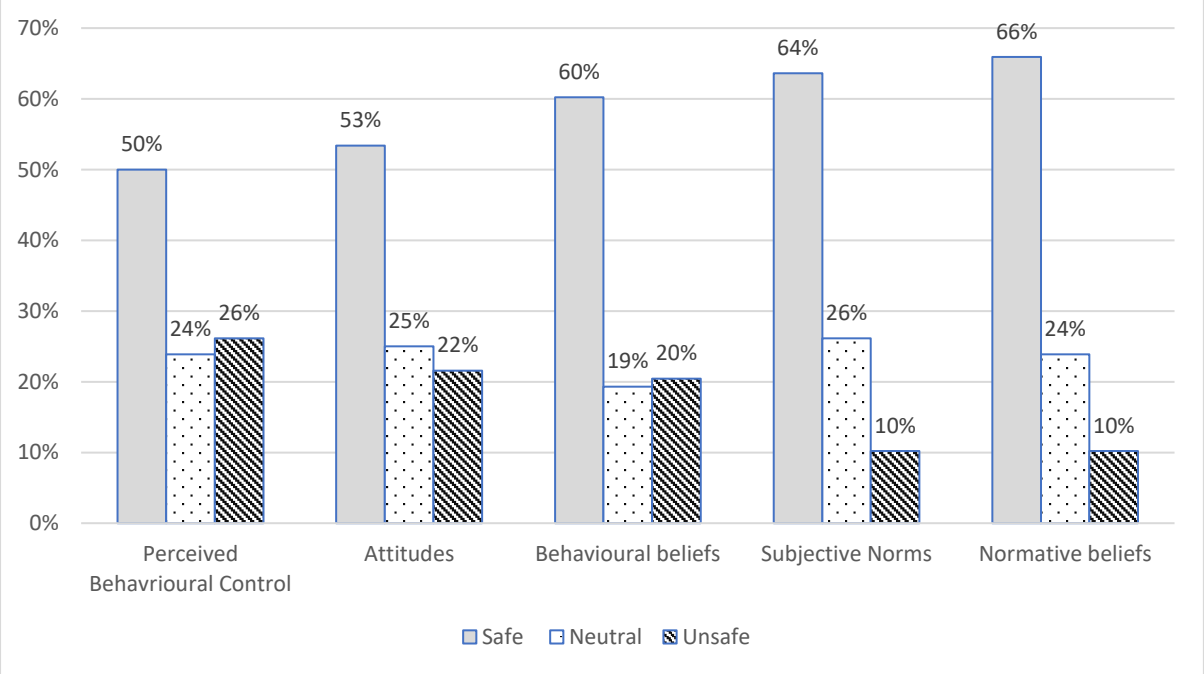

Figure 3. Behavioral intentions toward vaccination.

Results showed a strong correlation between attitudes, subjective norms, perceived behavioral control, and normative beliefs. In particular, the correlation between behavioral beliefs and perceived behavioral control was highest (r = .714) (Table 4).

Table 4. The non-parametric (Spearman's Rho) correlation between the determinants of behavioral intentions towards COVID-19 among participants.

	1	2	3	4
1. Subjective norms				
2. Perceived behavioral control	0.585**			
3. Behavioural beliefs	0.541**	0.714**		
4. Normative beliefs	0.591**	0.539**	0.674**	
5. Attitude	0.542**	0.598**	0.648**	0.561**

Note: **Correlation is significant at the 0.01 level (2-tailed).

Data were also analyzed to determine the extent to which reliance on the different sources of information was a predictor of behavioral intentions toward vaccination. Results showed no significant association between the reliance on the different sources of information and subjective norms (p = 0.184), as well as reliance on the different sources of information and perceived behavioral control (p = 0.499). Results (Table 5a) of the analysis of variance (ANOVA) for the regression model examine the relationship between attitudes toward vaccines (dependent variable) and reliance on various sources of information about COVID-19 (independent variables). The regression model showed that the predictors collectively accounted for a significant variance in attitudes toward vaccines (F = 3.109, p = 0.004). Table 5b shows the unstandardized coefficients (B), standardized coefficients (Beta), t-values, and significance levels for each predictor in the regression model. The predictors included social media, newspapers, community radio, television, research publications, textbooks, friends and family, and government announcements as sources of information about COVID-19.

Among these predictors, social media (Beta = 0.240, p = 0.041) and government announcements (Beta = 0.343, p = 0.017) were significantly associated with attitudes toward vaccination. The constant term (B = 1.151, p = 0.037) was also statistically significant. However, the other predictors (newspapers, community radio, television, research publications, textbooks, friends, and family) did not significantly correlate with attitudes toward vaccines. These results provide insights into which sources of information about COVID-19 influence attitudes toward vaccination. Social media and government announcements appear to have a significant impact, while the other sources did not show significant associations. These findings can inform public health communication strategies to target influential sources for promoting positive attitudes and vaccine acceptance.

Table 5a. The Analysis of Variance (ANOVA) for the Regression Model Examining Attitudes toward Vaccines and Reliance on Information Sources about COVID-19.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	40.158	8	5.020	3.109	0.004[b]
Residual	127.558	79	1.615		
Total	167.716	87			

Note: a. Dependent Variable: attitudes toward vaccines b. Predictors: (Constant), reliance on government announcements to learn about COVID-19, Reliance on textbooks to learn about COVID-19, Reliance on social media to learn about COVID-19, Reliance on science research articles to learn about COVID-19, Reliance on friends and family to learn about COVID-19, Reliance on newspapers to learn about COVID-19, Reliance on television to learn about COVID-19, Reliance on the radio to learn about COVID-19.

Table 5b. Regression Coefficients and Significance Levels for Predictors of Attitudes toward Vaccination based on Information Sources about COVID-19.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	1.151	.544		2.117	0.037
Social media	.248	.120	.240	2.075	0.041
Newspapers	-.106	.123	-.111	-.861	0.392
Community radio	.020	.141	.021	.145	0.885
Television	.046	.131	.046	.349	0.728
Research publications	.005	.118	.005	.046	0.963
Textbooks	.088	.119	.097	.741	0.461
Friends and family	-.077	.119	-.084	-.650	0.518
Government communique	.382	.156	.343	2.450	0.017

Note: a. Dependent Variable: attitudes toward vaccination.

Data were analyzed using the analysis of variance (ANOVA) for the regression model to examine the relationship between behavioral beliefs (dependent variable) and reliance on various sources of information about COVID-19 (independent variables) (Table 6a). The regression model showed that the predictors collectively accounted for a significant variance in behavioral beliefs ($F = 3.931$, $p < 0.001$). Table 6b shows the unstandardized coefficients (B), standardized coefficients (Beta), t-values, and significance levels for each predictor in the regression model. The predictors included social media, newspapers, community radio, television, research publications, textbooks, friends and family, and government announcements as sources of information about COVID-19.

Among these predictors, government announcements were significantly associated with behavioral beliefs (Beta = 0.448, $p = 0.001$). Social media (Beta = 0.208, $p = 0.067$) also showed a trend toward significance, but it did not reach the conventional level of significance ($p < 0.05$). The constant term (B = 1.100, $p = 0.041$) was statistically significant. The other predictors (newspapers, community radio, television, research publications, textbooks, friends, and family) did not show significant associations with behavioral beliefs. These results suggest that government announcements have a significant impact, while social media shows a trend toward significance.

Table 6a. Analysis of Variance (ANOVA) for the Regression Model Examining Behavioural Beliefs and Reliance on Information Sources about COVID-19.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	48.337	8	6.042	3.931	<0.001[b]
	Residual	121.436	79	1.537		
	Total	169.773	87			

Note: a. Dependent Variable: Behavioural beliefs b. Predictors: (Constant), Reliance on government announcements to learn about COVID-19, Reliance on textbooks to learn about COVID-19, Reliance on social media to learn about COVID-19, Reliance on science research articles to learn about COVID-19, Reliance on friends and family to learn about COVID-19, Reliance on newspapers to learn about COVID-19, Reliance on television to learn about COVID-19, Reliance on the radio to learn about COVID-19.

Table 6b. Regression Coefficients and Significance Levels for Predictors of Behavioural Beliefs Based on Information Sources about COVID-19.

	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	1.100	0.530		2.074	0.041
Social media	0.216	0.117	0.208	1.854	0.067
Newspapers	-0.093	0.120	-0.096	-0.774	0.441
Community radio	-0.066	0.138	-0.068	-0.483	0.631
Television	-0.163	0.128	-0.163	-1.275	0.206
Research publications	0.142	0.115	0.141	1.227	0.223
Textbooks	0.120	0.116	0.131	1.029	0.307
Friends and family	0.024	0.116	0.026	0.210	0.834
Government communique	0.502	0.152	0.448	3.301	0.001

Note: a. Dependent Variable: Behavioural beliefs.

Table 7a presents ANOVA results for the regression model on normative beliefs and COVID-19 information sources. The model accounted for significant variance in normative beliefs (F = 3.384, p = 0.002). Table 7b shows coefficients and significance levels for each predictor, including social media, newspapers, etc. Government announcements were significantly associated with normative beliefs (Beta = 0.347, p = 0.014), while other sources showed no significant associations. The results show that government announcements have a significant impact, while the other sources did not show significant associations.

Table 7a. Analysis of Variance (ANOVA) for the Regression Model Examining Normative Beliefs and Reliance on Information Sources about COVID-19.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	30.393	8	3.799	3.384	0.002[b]
Residual	88.687	79	1.123		
Total	119.080	87			

Note: a. Dependent Variable: Normative beliefs b. Predictors: (Constant), reliance on government announcements to learn about COVID-19, Reliance on textbooks to learn about COVID-19, Reliance on social media to learn about COVID-19, Reliance on science research articles to learn about COVID-19, Reliance on friends and family to learn about COVID-19, Reliance on newspapers to learn about COVID-19, Reliance on television to learn about COVID-19, Reliance on the radio to learn about COVID-19.

Table 7b. Regression Coefficients and Significance Levels for Predictors of Normative Beliefs Based on Information Sources about COVID-19.

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.674	.453		3.692	<.001
Social media	.084	.100	.096	.842	.402
Newspapers	-.093	.103	-.115	-.907	.367
Community radio	-.014	.118	-.017	-.122	.903
Television	.029	.109	.034	.263	.793
Research publications	.137	.099	.163	1.393	.168

Textbooks	.073	.100	.095	.734	.465
Friends and family	.022	.099	.029	.225	.823
Government communique	.326	.130	.347	2.509	.014

Note: a. Dependent Variable: Normative beliefs.

DISCUSSION

This research was conducted with the primary objective of elucidating the potential role of pre-service Life Sciences teachers in fostering health literacy, particularly in the context of the COVID-19 pandemic. It further sought to understand the relationship between the information sources utilized by these teachers and their behavioral intentions towards COVID-19 vaccination in light of the crucial public health role they could potentially fulfill.

An important finding of the study was the diverse range of information sources the pre-service Life Sciences teachers relied upon to learn about COVID-19. These sources included government communiques and traditional media outlets such as television and radio, as well as social media, research publications, and personal interactions with family and friends. A significant implication of this finding is the potential risk associated with misinformation from unreliable sources, notably social media, which has been highlighted by previous research [4,40]. The susceptibility to misinformation can be heightened by the "inattention" effect described by Pennycook et al [40], where users continue to share scientifically invalid and misleading content despite being able to distinguish it from valid information. This phenomenon could explain the high reliance on social media among our participants, raising concerns about the propagation of misinformation despite their awareness of the potential inaccuracies.

The risk of misinformation is particularly concerning in South Africa and other developing countries, where access to varied and reliable information sources might be limited. The high reliance on social media as an information source underscores the urgent need for targeted health communication strategies prioritizing disseminating accurate and scientifically valid information. Enhancing the health literacy of pre-service Life Sciences teachers is crucial, as they play a pivotal role in public health education [21]. By improving their ability to discern and disseminate reliable information, governments can mitigate the impact of misinformation and promote better health outcomes in these regions.

However, the advantages conferred by the scientific background of Life Sciences teachers should not be overlooked. Our findings indicate that access to various sources, including credible ones such as research publications, could mitigate the spread of misinformation. These teachers' training in the sciences equips them with scientific reasoning skills and an appreciation for evidence-based information [2,41]. This can enhance their ability to discern accurate from inaccurate content, consistent with previous research [40,42]. This suggests that the scientific literacy and cognitive reflection innate to their profession could serve as a buffer against misinformation. In the South African and broader developing world context, leveraging the scientific acumen of educators can be pivotal in counteracting the pervasive misinformation often found on social media. Furthermore, empowering teachers with reliable information sources can foster a more scientifically literate society, which is crucial for improving public health outcomes in these regions.

Interestingly, our findings also showed that the reliance on different sources of information did not predict subjective norms and perceived behavioral control. However, these constructs were found to be strongly correlated with other determinants of behavioral intentions. This could suggest that other factors influence these teachers' attitudes and behaviors related to vaccination, potentially unique to their professional or personal contexts, not captured in this study. This highlights an area for further research to gain a more comprehensive understanding of the determinants of vaccination intentions among this demographic. These findings imply that localized socio-cultural factors and personal experiences may significantly shape vaccination attitudes, particularly in the developing world.

Addressing these unique influences is essential for designing effective health communication strategies and improving vaccine uptake in these regions.

A noteworthy observation from our study was the significant influence of the information sources on attitudes toward vaccination and behavioral and normative beliefs about vaccination. This finding echoes previous research [7,8], adding a unique perspective from the lens of Life Sciences teachers. Particularly, social media and government communiques emerged as the most influential sources. Given the trust placed in these sources, as affirmed by our study and prior research [2,7,8,43,44], there is a pressing need to ensure the accuracy and validity of information disseminated through these channels. As Life Sciences teachers could play a key role in promoting health literacy and safe behaviors, the quality of information they access significantly impacts their potential to influence public health positively.

Our research underlines the complex interplay of information sources, cognitive processes, and behavioral intentions in the context of Life Sciences teachers. While the diversity of information sources poses potential risks in the propagation of misinformation, their scientific background can serve as a robust defense against such risks. However, to fully harness the potential of Life science teachers in promoting health literacy and safe behaviors, concerted efforts are needed to ensure the accuracy and validity of information, particularly on prominent platforms such as social media and government communiques. Future research could explore other determinants of their vaccination intentions to inform more targeted and effective health literacy initiatives.

Study limitations

This study, while providing valuable insights into the influence of information sources on COVID-19 vaccination intentions among pre-service Life Sciences teachers, is not without limitations. Firstly, the sample size was relatively small and drawn from a single university, which may limit the generalizability of the findings to a broader population of pre-service teachers in South Africa or other regions. Secondly, the study's cross-sectional design captures data at a single point in time, preventing the assessment of changes in attitudes and behaviors over time. Additionally, the reliance on self-reported data may introduce response biases, as participants might have provided socially desirable answers. Lastly, while the study identifies significant relationships between information sources and vaccination attitudes, it does not account for the potential influence of underlying personal, cultural, or socio-economic factors that could also play a critical role in shaping vaccination intentions [45-47]. Future research should consider longitudinal designs, more extensive and diverse samples, and the inclusion of qualitative methods to provide a more comprehensive understanding of the determinants of vaccination intentions in this important demographic.

CONCLUSION

This study concludes that pre-service Life Sciences teachers in South Africa rely on diverse information sources, with social media posing misinformation risks. Their scientific training helps mitigate these risks, influencing attitudes and beliefs toward COVID-19 vaccination. Further research is needed to understand other factors shaping their vaccination intentions. The study underscores pre-service Life Sciences teachers' significant role in promoting health literacy and safe behaviors, particularly regarding COVID-19 vaccination. The diversity of information sources they rely on, from government communique and traditional media to social media, research publications, and personal interactions, raises important considerations for health communication strategies. Notably, the potential risk of misinformation dissemination through unverified sources, especially social media, underscores the need for rigorous fact-checking and validity assurance of such platforms. However, the scientific background of these teachers offers a counterbalance to this challenge. Their understanding of scientific methodology and principles enhances their ability to distinguish between valid and invalid information, thereby potentially reducing the impact of misinformation.

Furthermore, these teachers' access to various sources of information, including credible ones, can help rectify any misinformation encountered. While the reliance on different information sources was not a predictor of subjective norms and perceived behavioral control, it significantly influenced

attitudes, behavioral beliefs, and normative beliefs toward vaccination. This suggests the presence of other influential factors on these constructs, warranting further investigation.

This study's findings bear implications for public health communication, especially regarding vaccination in a pandemic. Given the potential role of pre-service Life Sciences teachers in health literacy initiatives, ensuring they have access to accurate, valid, and reliable information is imperative. Simultaneously, the findings suggest that future research should delve deeper into other factors influencing vaccination intentions, subjective norms, and perceived behavioral control among teachers. Unraveling these influences will provide more nuanced insights, enabling more targeted interventions and support strategies for these pivotal health literacy agents. Further research could also explore the potential of such educational agents across different fields, extending the scope of impact.

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