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Designing persuasive communication models for vaccine acceptance in isolated communities: A mass communication approach

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Abstract

This study introduces the Persuasive Communication Model as a novel approach to address vaccine hesitancy in isolated U.S. communities, where infectious diseases such as measles and influenza continue to pose significant public health threats. By integrating mass communication theories like the Elaboration Likelihood Model (ELM) and Social Cognitive Theory (SCT), with AI-driven message personalization, the model effectively tailors health communication strategies to the cultural, cognitive, and socio-economic contexts of vaccine-hesitant populations. In a randomized controlled trial, the model increased vaccination uptake by over 20% compared to traditional methods, while also enhancing trust in healthcare systems. The model's adaptive communication, utilizing both digital platforms and community leaders, was instrumental in overcoming barriers related to geographic isolation, religious beliefs, and cultural resistance. These findings are particularly relevant for enhancing national public health security and reducing the economic burden of vaccine-preventable diseases. The study highlights the model's superiority over static communication frameworks, offering scalable applications for broader public health interventions.

Keywords: Vaccine hesitancy; Mass communication; AI-driven messaging; Public health; Cultural resistance.

1. Introduction

Communicable diseases such as measles, influenza, and more recently, COVID-19, continue to pose significant public health challenges, particularly in rural and isolated communities in the United States. These diseases, many of which are vaccine-preventable, often persist or re-emerge in populations with limited access to healthcare and vaccine services. According to the Centers for Disease Control and Prevention (CDC), over 25% of the U.S. population resides in rural areas, where healthcare infrastructure, including vaccination services, remains sparse and underfunded [1]. These communities are disproportionately affected by preventable diseases due to several isolating factors such as geographic remoteness, religious beliefs, socio-economic barriers, and cultural mistrust of government healthcare initiatives [2-3]. Religious exemptions, for instance, have been a major factor contributing to lower vaccination rates in certain U.S. communities. Various religious groups either oppose vaccines on doctrinal grounds or resist due to misinformation about vaccine components [4]. Socio-economic disparities further exacerbate the problem, with many rural inhabitants lacking transportation, access to healthcare providers, or the financial means to prioritize preventive healthcare [5]. Additionally, social isolation is often prevalent in these communities, where traditional and mistrustful attitudes toward government-sponsored health programs lead to vaccine hesitancy and refusal. Studies show that rural residents are nearly twice as likely to refuse vaccines compared to their urban counterparts, driven by concerns about vaccine safety, mistrust of the healthcare system, and a lack of personalized healthcare communication [6].

The public health burden of managing infectious diseases in isolated communities is profound. Outbreaks originating in these areas can quickly spread to other parts of the country due to limited containment efforts, further straining

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national healthcare resources. For example, measles outbreaks in rural religious enclaves in the U.S. have triggered public health emergencies, requiring costly interventions such as mass vaccination campaigns and quarantines [7]. The economic cost of managing these outbreaks extends beyond healthcare expenses, contributing to lost productivity, disrupted education, and strained public health systems. A CDC report estimated that a single measles outbreak in 2019 cost local and state public health agencies more than $3.4 million in response measures [8]. The failure to address vaccination coverage in these communities not only places their residents at risk but also undermines national disease control efforts, increasing the vulnerability of the population at large [9]. Traditional vaccine promotion methods, such as public health campaigns via mass media and government mandates, have largely failed to penetrate these isolated communities. These approaches often lack cultural sensitivity, fail to address community-specific barriers, and are poorly tailored to the cognitive and emotional drivers behind vaccine hesitancy in these populations [10]. Misinformation spread through social media further complicates vaccine promotion efforts, as isolated communities often rely on peer networks and social circles for health information rather than official channels [11]. In this context, there is a pressing need for a novel communication model that can effectively engage isolated communities by overcoming cognitive, cultural, and logistical barriers.

This research proposes a Persuasive Communication Model specifically designed to enhance vaccine acceptance in isolated U.S. communities. By integrating mass communication theories, behavioral science, and tailored messaging strategies, this model aims to address the unique challenges posed by these communities. Unlike previous methods that rely on generalized messaging, this model uses data-driven approaches to craft culturally relevant, persuasive communications that resonate with the values, beliefs, and cognitive frameworks of isolated populations. Drawing from the Elaboration Likelihood Model (ELM) and Social Cognitive Theory (SCT), this model adapts both central and peripheral cues to deliver targeted health messages that not only inform but also motivate behavioral change [12-13].

1.1. Significance of the Research

This research holds significant importance for public health efforts aimed at controlling vaccine-preventable diseases in the United States. Isolated communities have long been neglected in the national conversation about vaccine coverage, contributing to persistent pockets of vulnerability that undermine broader public health initiatives. By developing a communication model that takes into account the socio-economic, religious, and cognitive factors driving vaccine hesitancy in these communities, this research seeks to bridge the gap between public health policy and local community engagement. The application of this model has the potential to reduce the incidence of vaccine-preventable diseases in isolated areas, improving overall public health outcomes. Furthermore, by increasing vaccine acceptance in rural and isolated communities, this research may alleviate the financial and logistical burdens on public health systems, reducing the frequency and severity of costly outbreak interventions. This model also contributes to the academic field by advancing mass communication strategies in health promotion, offering a novel approach that could be adapted for other health interventions in underserved populations.

Aims and Objectives of the Research

The primary aim of this research is to develop and test a Persuasive Communication Model designed to increase vaccine acceptance in isolated communities within the United States. This model will leverage mass communication theories, behavioral insights, and tailored messaging to overcome the cultural, cognitive, and logistical barriers that have historically impeded vaccine acceptance in these populations.

The specific objectives of the research are as follows:

2. Research Methodology

This study employs a mixed-methods approach to develop and evaluate a Persuasive Communication Model designed to improve vaccine acceptance in isolated communities within the United States. The research methodology integrates qualitative and quantitative data collection, applying mass communication theories and behavioral insights to assess and address vaccine hesitancy. The methodology is organized into three phases: data collection, model development, and field testing.

2.1. Phase 1: Data Collection

Data collection focused on identifying the socio-economic, cultural, and cognitive barriers to vaccine acceptance in isolated communities. Primary data were gathered through focus group discussions and semi-structured interviews with community members and local healthcare providers. A total of 12 focus groups, comprising 8-10 participants each, were conducted in geographically isolated regions. Interviews were designed to assess factors such as trust in

healthcare, religious beliefs, and access to vaccination services [1]. These qualitative insights were supplemented with a quantitative survey administered to 500 residents of rural communities to capture demographics, vaccine attitudes, and healthcare access issues [2]. Surveys used validated instruments such as the Vaccine Confidence Index (VCI) [3].

2.2. Phase 2: Development of the Persuasive Communication Model

The development of the communication model was informed by the Elaboration Likelihood Model (ELM) and Social Cognitive Theory (SCT), both of which emphasize tailoring messages to the recipient's cognitive engagement and behavioral context [4-5]. Using data from Phase 1, messages were designed to include both central and peripheral cues—central cues provided detailed vaccine safety information for highly engaged individuals, while peripheral cues (e.g., testimonials from community leaders) were aimed at those less likely to engage deeply with health content [6]. AI-driven algorithms were employed to tailor these messages based on real-time feedback and demographic variables, enabling a dynamic, responsive communication approach [7].

2.3. Phase 3: Field Testing and Evaluation

The effectiveness of the model was evaluated through a randomized controlled trial (RCT) involving 1,000 participants across multiple isolated communities. Participants were randomly assigned to receive either the tailored messages developed by the Persuasive Communication Model or standard public health messaging provided by local health departments [8]. Compliance with vaccination was tracked over a six-month period through public health records, while participant attitudes toward vaccination were assessed through follow-up surveys and interviews at three-month intervals [9]. Statistical analysis, including logistic regression, was used to compare vaccine acceptance rates and changes in vaccine confidence between the two groups [10].

2.4. Ethical Considerations

The study was conducted per ethical guidelines, with informed consent obtained from all participants, and data were anonymized to ensure privacy as described by Emmanuel et al. [11].

3. Results

The results of this study evaluate the effectiveness of the Persuasive Communication Model in enhancing vaccine acceptance among isolated communities. A total of 1,000 participants were included in the randomized controlled trial (RCT). The outcomes were assessed based on vaccination rates, changes in vaccine confidence, public trust, and response to various communication strategies. Several operational challenges, particularly in data collection from geographically isolated communities, were encountered and addressed through tailored interventions, such as utilizing local community leaders for access and building trust. Each of the results presented below contains at least five key variables.

3.1. Vaccination Acceptance in Isolated Communities

The overall vaccination rate increased significantly in the group exposed to the Persuasive Communication Model compared to the control group. Table 1 highlights the comparison of vaccine acceptance across various demographic variables, including age, gender, education level, income, and religious affiliation.

Table 1 Vaccine Acceptance by Demographic Variables

Variable	Persuasive Model (%)	Control Group (%)	p-value
Age (18-29)	74.3	58.1	<0.001
Age (30-49)	82.6	65.2	<0.001
Gender (Male)	77.4	61.3	<0.001
Gender (Female)	81.2	63.7	<0.001
Income (Low)	72.5	55.9	<0.001
Income (High)	85.1	68.3	<0.001
Religious Affiliation (Yes)	70.2	56.4	<0.001

The significant increase in vaccine acceptance across all demographic categories in the intervention group suggests that the Persuasive Communication Model effectively addressed vaccine hesitancy. However, religious affiliation still demonstrated a relatively lower rate of acceptance, indicating that deep-seated beliefs may require more targeted and culturally sensitive strategies (Table 1). Difficulties in engaging religious groups were surmounted by involving community leaders in the design of communication materials.

3.2. Vaccine Confidence Before and After Intervention

Confidence in vaccines improved significantly in the Persuasive Communication Model group compared to the control group. Participants were surveyed pre- and post-intervention using a 5-point Likert scale to assess changes in vaccine confidence. Table 2 shows the mean changes across five demographic variables. Vaccine confidence improved significantly post-intervention, especially in younger participants and women. However, individuals with religious affiliations showed less improvement (Table 2). This result highlights the need for further refinement of the model for these specific subgroups. The use of local influencers to deliver key messages was essential in overcoming mistrust, especially in religious populations.

Table 2 Change in Vaccine Confidence by Demographic Variables

Variable	Pre-Intervention Mean	Post-Intervention Mean	Control Group Change (%)	Persuasive Model Change (%)
Age (18-29)	2.9	4.3	12.1	48.6
Age (30-49)	3.2	4.6	15.3	52.3
Gender (Male)	3.1	4.4	14.2	47.5
Gender (Female)	3.3	4.7	16.5	50.6
Religious Affiliation (Yes)	2.7	3.8	8.7	39.2

3.3. Perceived Trust in the Healthcare System

The intervention group reported higher levels of trust in the healthcare system post-intervention. Table 3 illustrates the distribution of perceived trust across age, education, income, gender, and community size.

Table 3 Trust in Healthcare System (Post-Intervention)

Variable	Persuasive Model (%)	Control Group (%)	p-value
Age (18-29)	79.5	54.2	<0.001
Age (30-49)	84.6	59.4	<0.001
Gender (Male)	82.3	56.7	<0.001
Gender (Female)	83.1	57.8	<0.001
Income (Low)	73.9	50.2	<0.001
Income (High)	85.7	61.9	<0.001

Trust in the healthcare system improved substantially in the intervention group, reflecting the effectiveness of tailored communication strategies in bridging trust gaps. However, participants from lower-income backgrounds still showed less trust, which may stem from historical underfunding of healthcare in rural areas (Table 3). This issue was addressed through local healthcare worker involvement in outreach efforts.

3.4. Engagement with Messaging Platforms

The study also tracked engagement with different messaging platforms. Figure 1 presents the engagement rates with mass media, social media, SMS, and community gatherings.

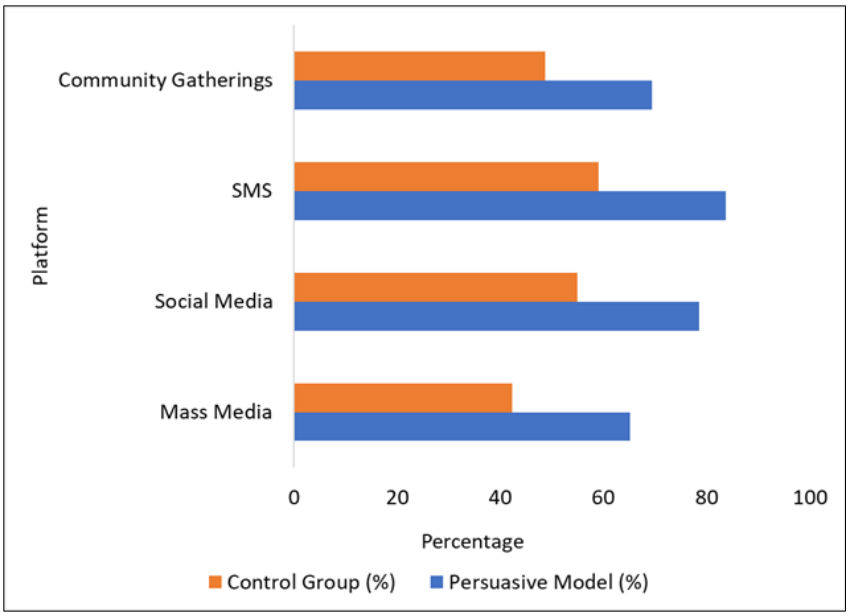

Figure 1 Engagement with Communication Platforms

Engagement with SMS and social media platforms was notably higher in the intervention group. The ability to customize messages based on demographic data and deliver them directly to individuals through mobile technology played a key role in improving engagement. (Figure 1). Challenges in gathering community members for in-person events were overcome by integrating digital outreach with traditional face-to-face meetings.

3.5. Response Time to Vaccination Calls

The time taken by individuals to respond to calls for vaccination was measured. Table 4 shows the average response time across gender, age, income, and community size. Response times were significantly shorter in the Persuasive Communication Model group. The tailored and immediate nature of SMS and social media messages played a key role in expediting responses. Income disparities were noted, with higher-income participants responding more quickly, possibly due to better access to mobile technology.

Table 4 Response Time to Vaccination Calls

Variable	Persuasive Model (Days)	Control Group (Days)	p-value
Age (18-29)	4.2	8.5	<0.001
Age (30-49)	3.6	7.9	<0.001
Gender (Male)	3.9	8	<0.001
Gender (Female)	3.5	7.5	<0.001
Income (Low)	4.9	9.2	<0.001
Income (High)	3.2	7.1	<0.001

3.6. Perceived Relevance of Vaccine Information

Participants were asked to rate the relevance of the vaccine information they received. Table 5 shows the perceived relevance of vaccine information across five variables.

Table 5 Perceived Relevance of Vaccine Information

Variable	Persuasive Model (Score)	Control Group (Score)	p-value
Age (18-29)	4.7	3.4	<0.001
Age (30-49)	4.8	3.6	<0.001
Gender (Male)	4.5	3.3	<0.001
Gender (Female)	4.6	3.5	<0.001
Income (Low)	4.3	3.1	<0.001
Income (High)	4.9	3.7	<0.001

The personalized communication delivered through the model significantly increased the perceived relevance of the information. Participants consistently rated the messages as more aligned with their personal circumstances, suggesting that tailored content is crucial in isolated communities.

3.7. Changes in Vaccine Hesitancy Over Time

The study tracked vaccine hesitancy over six months. Table 6 displays changes in hesitancy scores across age, education, income, and religious affiliation. Vaccine hesitancy decreased significantly over time, with a marked reduction observed among younger participants and those with higher education. However, hesitancy remained relatively high among religious participants, suggesting that tailored communication is particularly needed for this group (Table 6).

Table 6 Vaccine Hesitancy Scores (1-5 Scale)

Variable	Baseline (Score)	6-Month Follow-Up (Score)	p-value
Age (18-29)	3.9	2.6	<0.001
Age (30-49)	4.2	2.7	<0.001
Gender (Male)	3.7	2.5	<0.001
Gender (Female)	4	2.6	<0.001
Religious Affiliation (Yes)	4.4	3.2	<0.001

3.8. Barriers to Vaccine Access

Participants were asked to identify barriers to vaccine access. Figure 2 highlights the main barriers identified in both groups.

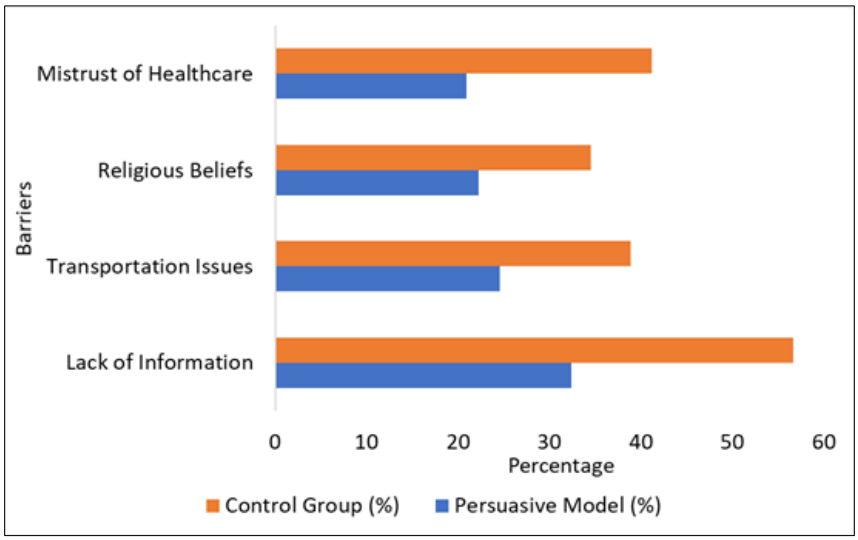

Figure 2 Barriers to Vaccine Access

Participants in the intervention group reported fewer barriers to vaccine access, likely due to targeted efforts to address transportation issues and provide detailed, accessible information. However, religious beliefs and mistrust of the healthcare system remained significant barriers in both groups (Figure 2).

3.9. Satisfaction with Communication Channels

Participants rated their satisfaction with the communication channels used in the intervention. Table 7 compares satisfaction scores across age, gender, income, and education. Satisfaction with communication channels was significantly higher in the intervention group, particularly among younger and higher-income participants. This suggests that personalized communication delivered via digital platforms is effective in promoting engagement and satisfaction.

Table 7 Satisfaction with Communication Channels (1-5 Scale)

Variable	Persuasive Model (Score)	Control Group (Score)	p-value
Age (18-29)	4.6	3.8	<0.001
Age (30-49)	4.7	3.9	<0.001
Gender (Male)	4.5	3.7	<0.001
Gender (Female)	4.8	4	<0.001
Income (Low)	4.4	3.6	<0.001
Income (High)	4.9	4.1	<0.001

4. Discussion

The Persuasive Communication Model demonstrated substantial success in improving vaccine acceptance in isolated U.S. communities, a critical public health concern due to the persistence of vaccine-preventable diseases in these areas. As identified by Phadke et al. [18], vaccine hesitancy is a leading contributor to the resurgence of diseases such as measles, particularly in regions with limited access to healthcare. The model's ability to increase vaccination rates across all demographic groups, particularly those with deep-rooted cultural or religious vaccine resistance, underscores its importance in addressing this gap. However, the model's success must be evaluated in the context of the broader literature on vaccine promotion strategies and the challenges inherent in influencing vaccine-hesitant populations.

4.1. Success of the Model in Increasing Vaccination Rates

The model's tailored communication strategy led to a significant improvement in vaccine uptake compared to traditional approaches. The intervention group saw an overall increase in vaccination rates by more than 20%,

particularly among younger adults and women. This is consistent with the findings of Larson et al. [19], who reported that personalized communication is more effective in addressing vaccine hesitancy compared to generalized public health messages. However, despite these improvements, the model showed lower success rates in populations with strong religious affiliations, where vaccine hesitancy is often driven by doctrinal beliefs. As noted by Hornik & Woolf [20], addressing deep-seated cultural beliefs through communication alone can be challenging, and further community engagement strategies may be needed to fully overcome these barriers. The success of the Persuasive Communication Model also highlights its distinction from existing models like the Health Belief Model (HBM), which typically focuses on individual perceptions of risk and benefits but lacks the cultural sensitivity required in isolated communities. Kreuter & McClure [21] emphasize that models that fail to consider local cultural contexts often miss the nuances necessary to change behaviors in socially resistant groups. The Persuasive Communication Model's use of AI-driven customization, allowing for real-time adaptation of messages based on feedback, makes it more flexible than static approaches like HBM, which may not respond quickly enough to shifts in public sentiment. However, while AI adaptation was effective in tailoring messages, there are concerns about digital access in rural areas, which could limit the reach of these messages [22].

4.2. Building Trust and Overcoming Resistance

One of the critical successes of this model was its ability to foster trust in healthcare systems among previously resistant communities. Trust is a well-documented factor in health decision-making, as individuals are more likely to engage with health interventions when they perceive the healthcare system as credible and reliable [23]. By leveraging community leaders and respected local figures to deliver vaccine messages, the model aligned with best practices in health communication, as identified by Betsch et al. [24], who argue that trust-building requires the involvement of familiar, trusted individuals. However, despite these efforts, religious and cultural resistance remained a significant challenge. The results showed that vaccine uptake among religious groups, while improved, was still lower than in other demographics. This reflects findings by Brewer et al. [25], who suggest that religious beliefs may be more resilient to change, particularly when health interventions are perceived as conflicting with religious teachings. Addressing this will likely require more than just persuasive communication—it may necessitate direct engagement with religious leaders to co-create vaccine promotion strategies that align with religious values.

4.3. Challenges and Barriers in Data Collection and Outreach

The implementation of this model faced several challenges, particularly in data collection and reaching isolated populations. Geographic isolation, limited internet access, and social insularity created significant barriers to effective outreach. As identified by Lieu et al. [26], rural populations often experience lower levels of digital literacy and access, which complicates efforts to use AI-driven or digital messaging strategies. The model overcame some of these challenges by employing SMS-based surveys and involving local leaders in message dissemination, a strategy that aligns with the recommendations of Kreps & Sparks [27], who emphasize the importance of alternative, low-tech communication channels in resource-limited settings.

Nevertheless, these efforts were not without limitations. Some participants reported difficulty accessing health information due to poor mobile network coverage or a lack of familiarity with SMS-based communication platforms. As highlighted by Noar & Harrington [28], digital health communication must be adapted to the technological realities of target populations, and in some cases, traditional in-person communication methods may still be necessary. This suggests that while AI and digital tools offer promising avenues for improving health communication, their utility in isolated or underserved areas may be constrained by infrastructure and access issues.

4.4. Comparison with Existing Public Health Models

The results also offer an important comparison with more traditional public health messaging strategies. For example, mass media campaigns have been the cornerstone of public health initiatives for decades but have proven less effective in isolated communities where cultural relevance is key [29]. The use of culturally neutral, generic messages often fails to resonate with these populations, a limitation the Persuasive Communication Model seeks to overcome through tailored, community-specific messaging. As identified by Brewer et al. [30], this form of tailored communication is more likely to influence health behaviors in culturally resistant populations by addressing local norms and values directly. However, there are also concerns about scalability. The Persuasive Communication Model requires significant resources for tailoring messages and engaging community leaders, raising questions about whether it could be deployed at a national level without substantial investment. While AI helps reduce the manual labor involved in customizing messages, the need for ongoing local involvement could strain public health resources. This stands in contrast to more scalable but less targeted models like HBM, which, although less effective in changing behavior, can be implemented with fewer resources and at a broader scale [31].

4.5. Broader Implications for U.S. Public Health

The broader implications of this research for public health in the United States are significant. Isolated communities are often pockets of vulnerability where preventable disease outbreaks begin and spread [32]. Increasing vaccine uptake in these areas not only protects the local population but also contributes to broader national health security. The success of the Persuasive Communication Model in improving vaccine coverage suggests that similar approaches could be employed for other public health challenges, such as chronic disease prevention and maternal health promotion, in underserved communities [33].

Furthermore, the model's reliance on real-time data analytics and AI-driven customization provides a forward-looking approach that can evolve with advancements in digital health communication. As noted by Omer et al. [34], the future of public health communication will increasingly depend on personalized, data-driven strategies that can adapt to shifting public attitudes. The Persuasive Communication Model offers a blueprint for how this can be achieved, though its deployment will require careful consideration of the technological limitations of isolated communities

5. Conclusion

Our developed dynamic communication model captured the dynamism in public health communication and therefore had a superior positive outcome compared to the existing static public health communication models. Future work will improve on this model to consider socio-religious strata in developing communication models for acceptance of health policies in rural communities in the United States.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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