Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

From Educational Seminars to Interpersonal Diffusion: Knowledge Fidelity in Word-of-Mouth Transmission of HPV Vaccine Information in Japan — A Real-World Implementation Study

Kayoko Katayama
kkatayama11@gunma-u.ac.jp

Gunma University
Yutaka Ueda
Wakayama Medical University
Masahiko Sakagushi
Kōchi University
Asami Yagi
Wakayama Medical University
Atsushi Ogihara
Waseda University
Mikiko Asai-Sato
St. Luke's International Hospital

Research Article

Keywords: HPV vaccine, diffusion of innovations, cervical cancer, word-of-mouth communication, knowledge fidelity, implementation science

Posted Date: May 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9675323/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: Competing interest reported. KK received an investigator-initiated research grant from MSD related to HPV vaccination research. The funders had no role in the design of the study; collection, analysis, or interpretation of data; or writing of the manuscript. The other authors declare no competing interests.

Version of Record: A version of this preprint was published at Implementation Science Communications on September 4th, 2026. See the published version at https://doi.org/10.1186/s43058-026-01096-6.

Abstract

Background

In vaccine-hesitant environments, evidence-based health information often spreads through interpersonal word-of-mouth communication within community networks. However, little empirical evidence exists regarding whether health knowledge remains accurate as it is transmitted across individuals. HPV vaccine hesitancy has persisted in Japan despite accumulating scientific evidence supporting vaccine safety and effectiveness. Conventional public health communication strategies have had limited impact in restoring public confidence. Implementation science emphasizes the importance of understanding how evidence-based interventions and information spread within real-world social contexts. Diffusion of innovations theory suggests that health information may spread through interpersonal communication within social networks, progressing from innovators to early adopters and subsequently to wider community members. However, empirical evidence regarding whether knowledge transmitted through interpersonal communication is preserved during the diffusion process remains limited.

Methods

This community-based observational pre–post study evaluated cervical cancer prevention seminars conducted by trained public health nurses in multiple regions of Japan between July 2023 and November 2024. Seminar participants (second learners) completed questionnaires assessing HPV vaccine–related knowledge immediately before and after the seminars. Participants were encouraged to share the information with family members or friends through interpersonal word-of-mouth communication, supported by a printed handout summarizing key messages. Individuals who subsequently received this information were defined as third learners and completed the same questionnaire online. Knowledge responses were categorized as correct, incorrect, or “do not know.” Knowledge fidelity was defined as the extent to which knowledge gained by second learners after the seminar was preserved when transmitted to third learners. Item response theory was used to estimate latent knowledge scores, and knowledge fidelity indices were calculated to quantify the proportion of knowledge gain retained during diffusion.

Results

A total of 299 second learners completed the pre-seminar questionnaire, 187 completed the post-seminar questionnaire, and 42 third learners completed the post-transmission survey. Correct response rates increased across all six knowledge items among second learners following the seminars. When information was transmitted to third learners through word-of-mouth communication, correct knowledge levels remained higher than baseline levels observed before the seminars. The estimated knowledge fidelity index indicated that approximately 45% of seminar-related knowledge gain was retained during

interpersonal transmission, demonstrating that a substantial proportion of evidence-based information was preserved during community diffusion. Regional analysis revealed variation in knowledge fidelity across communities, suggesting that contextual factors may influence how accurately information is preserved during diffusion.

Conclusions

Structured word-of-mouth communication within community networks can facilitate the transmission and partial retention of HPV vaccine knowledge beyond initial educational seminars. These findings suggest that interpersonal communication within trusted community networks may serve as a real-world implementation pathway for disseminating evidence-based health information in vaccine-hesitant contexts.

Introduction

Cervical cancer remains a significant public health issue worldwide, and vaccination against human papillomavirus (HPV) is recognized as one of the most effective strategies for its prevention (1). Japan represents a unique case among developed countries regarding HPV vaccine hesitancy following the suspension of proactive governmental recommendation in 2013 (2). The HPV vaccine was introduced into the national immunization program in 2013; however, shortly after its introduction, the government suspended proactive vaccine recommendations (3). Although proactive recommendation was reinstated in 2022 following extensive scientific evidence confirming vaccine safety and effectiveness, vaccine uptake has remained substantially lower than in other high-income countries (4). This situation illustrates a persistent gap between scientific evidence and public trust in health communication systems (5–7).

Health information often spreads through informal interpersonal communication within social networks, commonly referred to as word-of-mouth communication. Classic communication research has demonstrated that interpersonal networks play an important role in shaping the flow and interpretation of information (8–10). These interpersonal communication processes are central to Rogers' Diffusion of Innovations theory, which posits that new ideas and knowledge spread through social systems via communication among individuals (10). The challenges surrounding HPV vaccine re-promotion in Japan have also been discussed from a diffusion-of-innovations perspective (11). In community settings, individuals who receive health information from educational programs may subsequently share that information with family members, friends, or peers, thereby facilitating the diffusion of knowledge through everyday social interactions (12–15).

However, while previous research has examined how health information spreads through social networks, relatively little empirical evidence exists regarding how accurately information is preserved during interpersonal transmission. Information transmitted through word-of-mouth communication may be simplified, selectively interpreted, or modified during the communication process, potentially

influencing the accuracy of knowledge that reaches subsequent individuals (16, 17). Empirical evaluation of how well knowledge is preserved during community-based information diffusion therefore remains limited.

In this study, we introduce the concept of knowledge fidelity, defined as the extent to which the accuracy and essential content of health information are preserved when transmitted through word-of-mouth communication across individuals (18). Assessing knowledge fidelity allows evaluation not only of whether information spreads but also whether it spreads accurately.

We hypothesized that structured word-of-mouth communication embedded within trusted community relationships could function as a trust-mediated implementation strategy for disseminating HPV vaccine knowledge. Based on diffusion of innovations theory, trained public health nurses function as innovators who provide evidence-based information to community participants. These participants subsequently act as early adopters, communicating the information to their family members and peers through everyday interpersonal interactions. This perspective also aligns with broader implementation research emphasizing diffusion processes, contextual determinants, and implementation outcomes (19–21).

The primary objective of this study was to quantify the fidelity of HPV vaccine knowledge during structured word-of-mouth diffusion within community social networks by evaluating whether knowledge acquired through community-based cervical cancer prevention seminars was transmitted and retained when shared through interpersonal communication. A secondary objective was to examine contextual heterogeneity across communities and assess whether diffusion dynamics varied with community characteristics. To our knowledge, no previous empirical study has quantitatively evaluated the fidelity with which evidence-based vaccine knowledge is preserved during interpersonal word-of-mouth diffusion in real-world community settings.

Methods

Study Design and Setting

This study was a community-based, pre–post observational evaluation of an HPV vaccine education program conducted in multiple regions across Japan between July 2023 and November 2024. The program was implemented as part of routine public health activities delivered by public health nurses who served as first learners (innovators) in the diffusion process (10).

The study evaluated knowledge acquisition among seminar participants and examined whether HPV vaccine–related knowledge was preserved when transmitted through interpersonal word-of-mouth communication from seminar participants (15).

Participants were recruited through public health communication channels in each municipality. Announcements were disseminated through municipal health center newsletters, public bulletins, and official social media accounts to invite community residents, particularly parents and individuals within

the HPV vaccination target age group. Seminar announcements were also distributed to relevant organizations through local public health departments. Advance registration was required for all seminars. Flyers containing a QR code for online registration were distributed in each community.

Cervical Cancer and HPV Vaccine Education Program

The educational curriculum was developed by cancer prevention specialists and provided to public health nurses. Training content included the epidemiology of cervical cancer in Japan, the latest evidence on HPV vaccine safety and efficacy, vaccination schedules, and common misconceptions about HPV vaccination (7, 22).

Public health nurses (innovators) received evidence-based training from cancer specialists and delivered cervical cancer prevention seminars to community participants (early adopters). Participants completed pre- and post-seminar surveys to assess knowledge acquisition. After the seminars, participants shared the information with family members or friends through structured word-of-mouth communication supported by a printed handout. These recipients (early majority) subsequently completed a post-transmission survey, allowing evaluation of knowledge fidelity during interpersonal diffusion.

Public health nurses who completed the training served as first learners (innovators) in the dissemination process. These nurses collaborated with the research team and conducted cervical cancer prevention seminars for community residents and other interested participants.

Within this diffusion model, trained public health nurses introduced evidence-based information to community participants, initiating subsequent interpersonal dissemination through community networks (Fig. 1).

Community members who attended the seminars were defined as second learners (early adopters).

Word-of-Mouth Dissemination

Before the seminar began, participants received a brief explanation of the study and the concept of interpersonal diffusion based on diffusion of innovations theory (10). They were asked to consider in advance whom they might wish to share the information with and to attend the seminar while keeping a potential recipient of the information in mind (10).

After attending the seminar, second learners were encouraged to share the information they had learned with at least one family member or close friend. In this study, structured word-of-mouth communication refers to interpersonal information sharing intentionally supported by pre-seminar priming, post-seminar encouragement, and the use of standardized printed educational materials. During the seminars, participants were explicitly encouraged to communicate key messages about cervical cancer prevention

and HPV vaccination to their intended recipients after the seminar. They were also advised that using the printed handout provided during the seminar could facilitate accurate explanation of the information.

Individuals who received this information through interpersonal communication were defined as third learners (early majority). Third learners subsequently completed the same questionnaire online after receiving information through word-of-mouth communication from second learners.

To support accurate transmission of information, second learners received a printed handout summarizing key messages about cervical cancer prevention and HPV vaccination presented during the seminar. They were encouraged to use this material when sharing the information with family members or peers.

Participants

Participants in the diffusion process were categorized according to their role in the diffusion process. Community residents who attended the cervical cancer prevention seminars were defined as second learners. Family members or friends who subsequently received information through word-of-mouth communication from second learners were defined as third learners.

Participation in the surveys was voluntary and anonymous. No randomization or control group was employed because the study aimed to evaluate knowledge diffusion within a real-world community implementation context.

Because third learners were recruited through voluntary interpersonal communication initiated by second learners, participation depended on real-world interpersonal interactions and willingness of recipients to respond to the survey. As a result, the number of third learners was smaller than the number of seminar participants.

Ethical approval

for this study was obtained from the Human Subjects Ethics Review Committee of Gunma University. This study is reported in accordance with the STROBE guidelines for observational studies.

Knowledge Measurement and Definition of Knowledge Fidelity

HPV vaccine–related knowledge was assessed using a structured questionnaire administered to second learners immediately before and after the seminar. Third learners completed the same questionnaire online after receiving information through word-of-mouth communication.

The questionnaire consisted of six knowledge items covering HPV infection, vaccine effectiveness, vaccination schedules, and common misconceptions regarding HPV vaccination (7). For each item, participants selected one of three response options: correct, incorrect, or “do not know.”

In this study, knowledge fidelity was defined as the extent to which correct knowledge acquired by second learners after the seminar was preserved when transmitted to third learners through interpersonal communication. Knowledge fidelity was evaluated by comparing the distribution of responses between second learners in the post-seminar survey and third learners in the post-transmission survey.

To facilitate accurate information transmission, second learners were provided with a printed handout summarizing key messages from the seminar and were encouraged to use this material when explaining the information to family members or peers.

Statistical Analysis

Descriptive statistics were used to summarize participant characteristics and response distributions. Knowledge responses were categorized as correct, incorrect, or “do not know.”

Among second learners, changes in knowledge before and after the seminar were evaluated by comparing the distribution of responses between the pre-seminar and post-seminar surveys.

To evaluate knowledge transmission through word-of-mouth communication, responses from third learners were compared with the post-seminar responses of second learners.

Knowledge fidelity was assessed by examining whether the proportion of correct responses observed among second learners after the seminar was preserved among third learners who received the information through word-of-mouth communication. The fidelity index operationalizes this concept by quantifying the proportion of knowledge gain retained during interpersonal diffusion (18).

All statistical analyses were conducted using R statistical software (R Foundation for Statistical Computing, Vienna, Austria), version 4.5.2. A two-sided p-value < 0.05 was considered statistically significant.

Item response theory (IRT) analysis was performed to estimate latent knowledge ability scores (θ)(23). To quantify the degree to which knowledge gained during the seminar was retained during subsequent word-of-mouth diffusion, a knowledge fidelity index was calculated as:

$$\text{Knowledge fidelity} = \frac{\theta_{third} - \theta_{second_pre}}{\theta_{second_post} - \theta_{second_pre}}$$

This index represents the proportion of knowledge gain achieved by second learners after the seminar that was retained when the information was transmitted to third learners through interpersonal communication.

The latent knowledge ability scale (θ) was anchored to the mean ability level of second learners before the seminar, enabling comparison of knowledge changes following the seminar and the extent of knowledge retention among third learners.

Results

Participant characteristics

A total of 299 second learners participated in the cervical cancer prevention seminars, and 42 third learners completed the post-transmission survey after receiving information through word-of-mouth communication. Among the second learners, 299 completed the pre-seminar questionnaire and 187 completed the post-seminar questionnaire.

Participant characteristics are summarized in Table 1. The seminars were conducted in four municipalities in Japan that differed in population size and community structure. Osaka City (population 2.75 million) and Nishinomiya City (484,000) represent large urban municipalities in the Kansai metropolitan region.

Maebashi City (332,000) is a mid-sized regional city in central Japan, whereas Nose Town (9,200) is a small rural municipality (Table 2).

Second learners attended community-based cervical cancer prevention seminars led by trained public health nurses. Third learners subsequently received HPV vaccine–related information through word-of-mouth communication from second learners within their family or peer networks.

Knowledge change among second learners

Substantial improvements in HPV vaccine–related knowledge were observed among second learners following the educational seminar (Fig. 2).

Correct response rates increased across all six knowledge items. The largest improvement was observed for the item “HPV vaccination has been shown to be safe,” where the correct response rate increased from 27.5% before the seminar to 87.2% after the seminar.

Similarly, knowledge regarding the relationship between HPV infection and cervical cancer increased from 87.1% to 97.2%, and awareness that HPV is a common sexually transmitted infection increased from 74.2% to 96.1%.

These findings indicate that the structured seminar effectively improved HPV vaccine–related knowledge among second learners prior to the subsequent word-of-mouth communication process. Changes in response distributions between pre- and post-seminar surveys were statistically significant for all six knowledge items (all $p < 0.001$). Detailed response distributions are presented in Table 3.

Knowledge retention during word-of-mouth communication

To evaluate the accuracy of information transmitted through interpersonal communication, we introduced the concept of knowledge fidelity.

To evaluate whether knowledge acquired during the seminar was transmitted and retained during word-of-mouth communication, responses from third learners were compared with those from second learners after the seminar (Table 3).

Across most knowledge items, correct response rates among third learners remained relatively high, suggesting that knowledge obtained during the seminar was transmitted and partially retained during subsequent interpersonal communication.

For example, correct response rates among third learners were 88.1% for the item “HPV infection causes cervical cancer,” 83.3% for “HPV is a common sexually transmitted infection,” and 90.5% for “HPV vaccination requires multiple doses.”

However, knowledge retention varied by item. In particular, the correct response rate for “HPV vaccination has been shown to be safe” decreased to 59.5% among third learners, with 26.2% responding “Don’t know.”

Comparisons between second learners after the seminar and third learners showed statistically significant differences for five of the six knowledge items (Table 3), whereas no significant difference was observed for the item regarding the need for multiple vaccine doses ($p = 0.256$).

Overall knowledge fidelity

Latent knowledge ability scores estimated using item response theory demonstrated that knowledge increased substantially among second learners after the seminar and was partially retained among third learners following word-of-mouth diffusion within community networks (Fig. 3).

The mean latent knowledge score increased from $\theta = 0.007$ before the seminar to $\theta = 0.736$ after the seminar, representing a substantial improvement in knowledge among second learners. Among third learners, the mean knowledge score was $\theta = 0.337$, indicating partial retention of knowledge following word-of-mouth communication.

The resulting knowledge fidelity index was 0.45, indicating that approximately 45% of the seminar-related knowledge gain was retained during word-of-mouth diffusion.

Regional variation in word-of-mouth knowledge fidelity

Substantial regional variation in knowledge fidelity during word-of-mouth communication was observed across municipalities (Fig. 4).

Knowledge fidelity was highest in Nishinomiya City (1.27), indicating that knowledge transmitted through word-of-mouth communication exceeded the knowledge gain observed immediately after the seminar.

High fidelity was also observed in Maebashi City (0.92) and Osaka City (0.87), suggesting that knowledge acquired during the seminar was partially retained during word-of-mouth diffusion in these urban settings.

In contrast, Nose Town showed a markedly negative fidelity index (-1.93), indicating substantial reduction in knowledge fidelity during word-of-mouth transmission relative to baseline levels.

Knowledge fidelity indices derived from item response theory–based knowledge scores are shown for each study region (Nishinomiya City, Osaka City, Maebashi City, and Nose Town). The fidelity index represents the proportion of seminar-related knowledge gain retained during transmission from second learners to third learners through word-of-mouth communication.

Values close to 1 indicate that knowledge gains observed immediately after the seminar were largely preserved during interpersonal transmission, whereas lower or negative values indicate reduced preservation of knowledge during the diffusion process.

Discussion

Principal findings

This study examined whether knowledge related to cervical cancer prevention and HPV vaccination acquired through community-based seminars could be transmitted and preserved through interpersonal word-of-mouth communication within community social networks. The findings demonstrate that knowledge gained by seminar participants was partially retained during subsequent interpersonal transmission to third learners. These results suggest that structured word-of-mouth communication can facilitate the dissemination of evidence-based health information beyond the initial seminar participants. The analysis also showed that the magnitude of knowledge gain varied across individual knowledge items. Knowledge related to HPV vaccine safety showed the largest improvement after the seminar and remained substantially higher among third learners compared with baseline levels. This finding is notable because safety concerns have been a major driver of HPV vaccine hesitancy in Japan (2, 3).

Knowledge fidelity in community information diffusion

A central contribution of this study is the introduction and empirical evaluation of the concept of knowledge fidelity in community-based information diffusion. In this study, knowledge fidelity was defined as the extent to which correct knowledge acquired through educational seminars was preserved when transmitted through interpersonal word-of-mouth communication.

While diffusion of innovations theory has long emphasized the role of interpersonal communication in the spread of innovations (10), empirical evaluation of the accuracy of information transmitted through

such communication channels has been limited. The present findings suggest that interpersonal transmission does not necessarily lead to substantial degradation of knowledge and that accurate information can be retained when dissemination occurs within trusted social relationships (24). These observations are consistent with classic communication research showing that interpersonal networks play a central role in shaping the flow and interpretation of information (8, 9, 25). They also highlight that knowledge diffusion and knowledge preservation are distinct processes. Although information may spread through social networks, the degree to which transmitted information retains its original accuracy may vary depending on communication context and social dynamics. In other words, diffusion of health information does not necessarily guarantee the preservation of knowledge fidelity. This pattern may reflect the nature of interpersonal communication. Unlike information delivered directly through structured educational settings, word-of-mouth communication inevitably depends on the communicator's understanding, interpretation, and communication skills (15). In this study, participants were encouraged to use printed handouts when sharing information in order to support the preservation of knowledge fidelity; however, maintaining full knowledge fidelity during interpersonal transmission may remain challenging.

Regional variation in knowledge fidelity

An additional important finding was the presence of regional variation in knowledge fidelity across study sites. In Nishinomiya City, Osaka City, and Maebashi City, knowledge fidelity indices indicated that a substantial proportion of seminar-related knowledge gain was preserved during word-of-mouth transmission. In contrast, the fidelity index in Nose Town appeared to be lower, suggesting that the knowledge gain observed immediately after the seminar was not preserved during subsequent word-of-mouth communication. Nose Town is a super-aging rural community where interpersonal communication networks may be highly localized and shaped by long-standing social relationships. Such contextual characteristics may influence how health information is interpreted and transmitted within tightly connected local networks. However, the present study was not designed to determine which specific community-level factors contributed to the observed variation. In addition, the number of third learners in this study was relatively small overall (n = 42), and age distributions of second learners (post-seminar respondents) and third learners by municipality are shown in Supplementary Table S1. Therefore, the observed regional variation should be interpreted with caution. Nevertheless, these findings suggest that the effectiveness of word-of-mouth communication as an information dissemination mechanism may be context dependent. Local social structures and community characteristics may influence whether accurate knowledge is preserved or modified during interpersonal transmission (25, 26). The concept of knowledge fidelity may provide a useful framework for evaluating not only whether health information spreads within communities but also whether it remains accurate during interpersonal diffusion.

The proportion of third learners in this study (approximately 14% of second learners) is notable in light of diffusion of innovations theory, which suggests that transitions from early adopters to the early majority often occur after adoption by roughly 16% of a population, suggesting that interpersonal diffusion

observed in this study may reflect early-stage community diffusion dynamics. In the present study, 42 third learners were identified among 299 second learners who participated in the seminars, corresponding to approximately 14% of the second learner population. This proportion indicates that interpersonal diffusion beyond the initial seminar participants did occur. In diffusion of innovations theory, the transition from early adopters to the early majority is often described as occurring after adoption by roughly 16% of a population (10, 11). Although the learner categories used in this study do not directly correspond to Rogers' adopter categories, the observed proportion suggests that the diffusion process may have approached the boundary between the early adopter stage and broader community diffusion. Future studies with larger downstream learner populations will be needed to determine whether knowledge fidelity is maintained as diffusion expands further within community networks.

Trust and the limits of the information-deficit model

The observed regional variation also has implications for understanding HPV vaccine hesitancy in Japan. Public discourse surrounding HPV vaccination has often assumed that hesitancy results primarily from a lack of accurate information. However, the present findings suggest that the relationship between scientific accuracy and public acceptance may be more complex (16, 17, 27).

Even when accurate information is transmitted through interpersonal networks, the extent to which that information is retained or accepted may depend on the level of trust within the communication environment. In this context, the results support the view that HPV vaccine hesitancy in Japan cannot be explained solely by an information deficit but may also reflect broader issues of trust in health communication (6, 7, 27–29).

Strengths and limitations

This study has several strengths. First, the study evaluated information diffusion within real-world community settings rather than controlled experimental environments. Second, the study introduced a quantitative framework for evaluating knowledge fidelity during interpersonal information transmission, using item-response theory–based knowledge scores. Third, the study examined diffusion processes across multiple communities, allowing exploration of contextual variation in knowledge preservation.

Several limitations should also be acknowledged. First, the study did not directly observe the conversations between second learners and third learners; therefore, it was not possible to determine precisely how information was modified during interpersonal communication. However, to facilitate accurate transmission, participants were provided with a printed handout summarizing key information from the seminar and were encouraged to use this material when sharing the information with family members or peers. Second, the number of third learners was relatively small compared with the number of seminar participants, which may limit the ability to examine potential differences across communities. Background characteristics of third learners were not sufficiently detailed, and the sample size was small; therefore, the influence of individual characteristics on knowledge retention could not be examined. Finally, because the study was conducted in selected communities, the findings may not be

fully generalizable to other populations or settings. In addition, participation by third learners depended on voluntary interpersonal communication initiated by second learners and on their willingness to complete the survey. Therefore, individuals with stronger interpersonal relationships, greater interest in health topics, or higher communication engagement may have been more likely to participate, potentially introducing selection bias into the observed diffusion process.

Implications for implementation research

Despite these limitations, the present study provides empirical evidence that structured word-of-mouth communication can serve as a mechanism for disseminating evidence-based health information within community social networks. The concept of knowledge fidelity may provide a useful framework for evaluating the quality of information transmitted during community-based health communication. Future research should examine how contextual factors, including community structure, trust networks, and prior beliefs, influence the fidelity of information transmitted through interpersonal communication (25–29).

These findings suggest that word-of-mouth communication can serve as a community-based pathway for disseminating evidence-based health information, but the fidelity with which knowledge is preserved during diffusion may depend on local social context and trust structures.

Future studies should also examine whether preservation of HPV vaccine knowledge through interpersonal diffusion ultimately contributes to increased vaccine uptake and preventive health behaviors.

Conclusions

This study provides empirical evidence that structured word-of-mouth communication within community networks can facilitate the transmission and partial retention of HPV vaccine knowledge beyond the initial seminar participants.

Although knowledge attenuation occurred during interpersonal diffusion, a substantial proportion of seminar-related knowledge was preserved during transmission. These findings suggest that word-of-mouth communication may represent a scalable pathway for disseminating evidence-based health information in vaccine-hesitant contexts, while also highlighting the importance of community context and social trust in shaping how health information spreads.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Review Committee for Medical Research Involving Human Subjects at Gunma University (Approval Number: HS2021-077, approved July 31, 2024). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Informed consent was obtained from all participants prior to data collection. For online participants across all municipalities (Osaka, Nishinomiya, Maebashi, and Nose Town), study objectives and participation conditions were clearly explained on a dedicated webpage. Participants were required to actively check a consent checkbox before proceeding to the questionnaire; those who did not provide consent were unable to access the survey. For walk-in participants in Nose Town who registered on the day of the seminar, written informed consent was obtained using a paper-based consent form prior to participation.

Consent to Participate

Informed consent was obtained from all individual participants included in this study prior to data collection. Online participants provided active consent by checking a mandatory consent checkbox on a dedicated webpage before accessing the questionnaire. Walk-in participants in Nose Town provided written informed consent on the day of participation using a paper-based consent form.

Consent for publication

Not applicable.

Availability of data and materials

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

Competing interests

KK received an investigator-initiated research grant from MSD related to HPV vaccination research. The author declares no other competing interests.

Funding

This study was supported by a Grant-in-Aid for Scientific Research (KAKENHI, Grant Number JP23K21583) from the Japan Society for the Promotion of Science and by an investigator-initiated research grant from MSD.
The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; or in writing the manuscript. Support in part by a research grant from Investigator-Initiated Studies Program of Merck Sharp & Dohme Corp./ MSD K.K. The opinions expressed in this paper are those of the authors and do not necessarily represent those of Merck Sharp & Dohme Corp./MSD K.K.

Authors' contributions

KK conceptualized the study, designed the research, conducted the analysis, and drafted the manuscript. All authors contributed to the interpretation of the data, critically revised the manuscript, and approved the final version of the manuscript.

Acknowledgments

The author sincerely thanks the staff of the Nishinomiya City Health Center, the Health Promotion Division of the Osaka City Public Health Bureau, the public health nurses and administrative staff of Nose Town, and the Cancer Control Promotion Division of Gunma Prefecture for their invaluable collaboration and support in implementing community-based seminars and surveys for this study. The author also appreciates the participation of community residents who attended the seminars and contributed to the surveys.

References

1. Arbyn M, Xu L, Simoens C, Martin-Hirsch PP. Prophylactic vaccination against human papillomaviruses to prevent cervical cancer and its precursors. Cochrane Database Syst Rev. 2018;5:CD009069. 10.1002/14651858.CD009069.pub3.
2. Hanley SJB, Yoshioka E, Ito Y, Kishi R. HPV vaccination crisis in Japan. Lancet. 2015;385(9987):2571. 10.1016/S0140-6736(15)61152-7.
3. Ikeda S, Ueda Y, Yagi A, Matsuzaki S, Kobayashi E, Kimura T, et al. HPV vaccination in Japan: what is happening in Japan? Expert Rev Vaccines. 2019;18(4):323–5. 10.1080/14760584.2019.1584040.
4. Bruni L, Saura-Lázaro A, Montoliu A, Brotons M, Alemany L, Diallo MS, et al. HPV vaccination introduction worldwide and WHO and UNICEF estimates of national HPV immunization coverage 2010–2019. Prev Med. 2021;144:106399. 10.1016/j.ypmed.2020.106399.
5. MacDonald NE. Vaccine hesitancy: definition, scope and determinants. Vaccine. 2015;33(34):4161–4. 10.1016/j.vaccine.2015.04.036.
6. Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger J. Vaccine hesitancy: an overview. Hum Vaccin Immunother. 2013;9(8):1763–73. 10.4161/hv.24657.
7. Larson HJ, Jarrett C, Eckersberger E, Smith DMD, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination. Vaccine. 2014;32(19):2150–9. 10.1016/j.vaccine.2014.01.081.
8. Katz E, Lazarsfeld PF. Personal influence: the part played by people in the flow of mass communications. New York: Free; 1955.
9. Southwell BG, Yzer MC. The roles of interpersonal communication in mass media campaigns. Ann Int Commun Assoc. 2007;31(1):420–62. 10.1080/23808985.2007.11679072.
10. Rogers EM. Diffusion of innovations. 5th ed. New York: Free; 2003.
11. Ueda Y, Katayama K, Yagi A, Kimura T. The Chasm We Must Cross in Japan for Re-promotion of the HPV Vaccine. Cancer Prev Res (Phila). 2021;14(7):683–6. 10.1158/1940-6207.CAPR-21-0091.
12. Granovetter MS. The strength of weak ties. Am J Sociol. 1973;78(6):1360–80. 10.1086/225469.
13. Centola D. The spread of behavior in an online social network experiment. Science. 2010;329(5996):1194–7. 10.1126/science.1185231.

14. Lewandowsky S, Ecker UKH, Seifert CM, Schwarz N, Cook J. Misinformation and its correction: continued influence and successful debiasing. Psychol Sci Public Interest. 2012;13(3):106–31. 10.1177/1529100612451018.
15. Berger J. Word of mouth and interpersonal communication: a review and directions for future research. J Consumer Psychol. 2014;24(4):586–607. 10.1016/j.jcps.2014.05.002.
16. Nyhan B, Reifler J. When corrections fail: the persistence of political misperceptions. Polit Behav. 2010;32:303–30. 10.1007/s11109-010-9112-2.
17. Betsch C, Renkewitz F, Betsch T, Ulshöfer C. The influence of vaccine-critical websites on perceiving vaccination risks. J Health Psychol. 2010;15(3):446–55. 10.1177/1359105309353647.
18. Carroll C, Patterson M, Wood S, Booth A, Rick J, Balain S. A conceptual framework for implementation fidelity. Implement Sci. 2007;2:40. 10.1186/1748-5908-2-40.
19. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. Milbank Q. 2004;82(4):581–629. 10.1111/j.0887-378X.2004.00325.x.
20. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci. 2009;4:50. 10.1186/1748-5908-4-50.
21. Proctor EK, Silmere H, Raghavan R, Hovmand P, Aarons G, Bunger A, et al. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. Adm Policy Ment Health. 2011;38(2):65–76. 10.1007/s10488-010-0319-7.
22. Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing vaccination: putting psychological science into action. Psychol Sci Public Interest. 2017;18(3):149–207. 10.1177/1529100618760521.
23. Embretson SE, Reise SP. Item response theory for psychologists. Mahwah (NJ): Lawrence Erlbaum Associates; 2000.
24. Brunson EK. The impact of social networks on parents' vaccination decisions. Pediatrics. 2013;131(5):e1397–404. 10.1542/peds.2012-2452.
25. Granovetter MS. Threshold models of collective behavior. Am J Sociol. 1978;83(6):1420–43. 10.1086/226707.
26. Centola D, Macy M. Complex contagions and the weakness of long ties. Am J Sociol. 2007;113(3):702–34. 10.1086/521848.
27. Valente TW. Network interventions. Science. 2012;337(6090):49–53. 10.1126/science.1217330.
28. Southwell BG, Thorson EA, Sheble L. The persistence and diffusion of misinformation. Am Behav Sci. 2018;62(9):1159–73. 10.1177/0002764218766223.
29. Southwell BG, Niederdeppe J, Cappella JN, Gaysynsky A, Kelley DE, Oh A, et al. Misinformation as a misunderstood challenge to public health. Am J Prev Med. 2019;57(2):282–5. 10.1016/j.amepre.2019.03.009.

Tables

Tables are available in the Supplementary Files section.

Figures

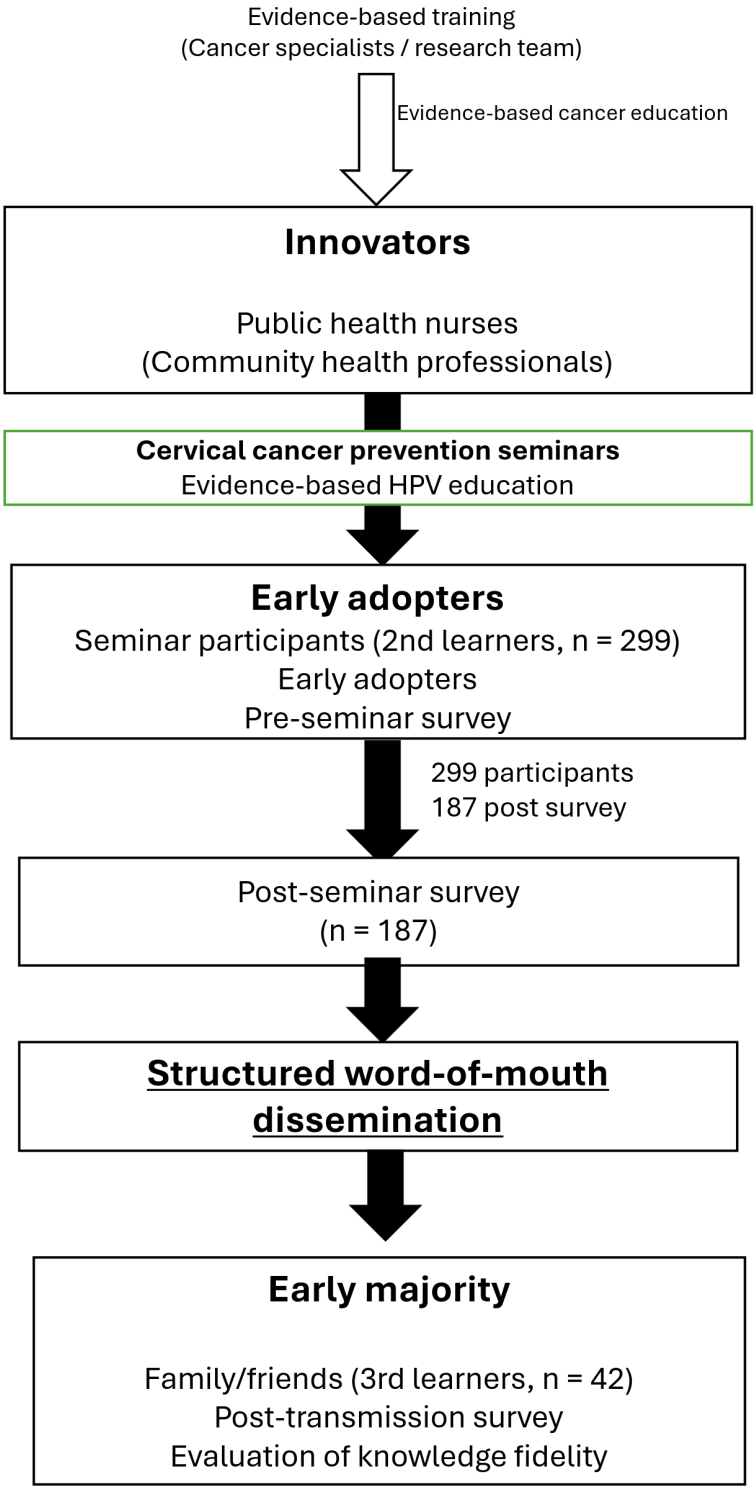

Figure 1

Conceptual framework of structured word-of-mouth dissemination.

Public health nurses (innovators) received evidence-based training from cancer specialists and delivered cervical cancer prevention seminars to community participants (early adopters). Participants completed pre- and post-seminar surveys to assess knowledge acquisition. After the seminars, participants shared the information with family members or friends through structured word-of-mouth communication supported by a printed handout. These recipients (early majority) subsequently completed a post-transmission survey, allowing evaluation of knowledge fidelity during interpersonal diffusion.

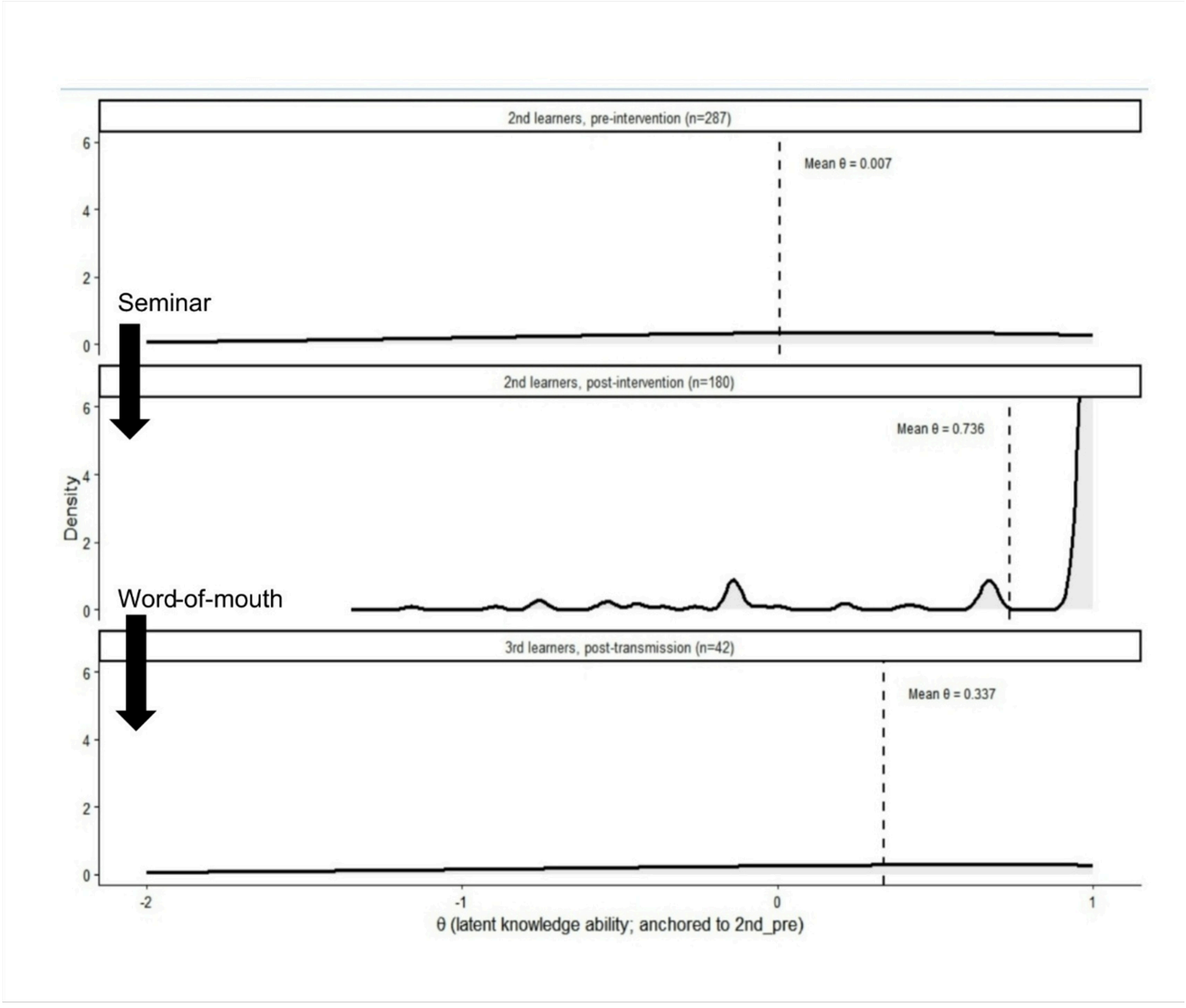

Figure 2

Distribution of latent HPV vaccine knowledge ability (θ) across study groups. Kernel density distributions of latent HPV vaccine knowledge ability (θ), estimated using item response theory, are shown for second learners before and after the seminar and for third learners after word-of-mouth

communication. Vertical dashed lines indicate mean θ values for each group. The θ scale was anchored to the baseline knowledge level of second learners before the seminar.

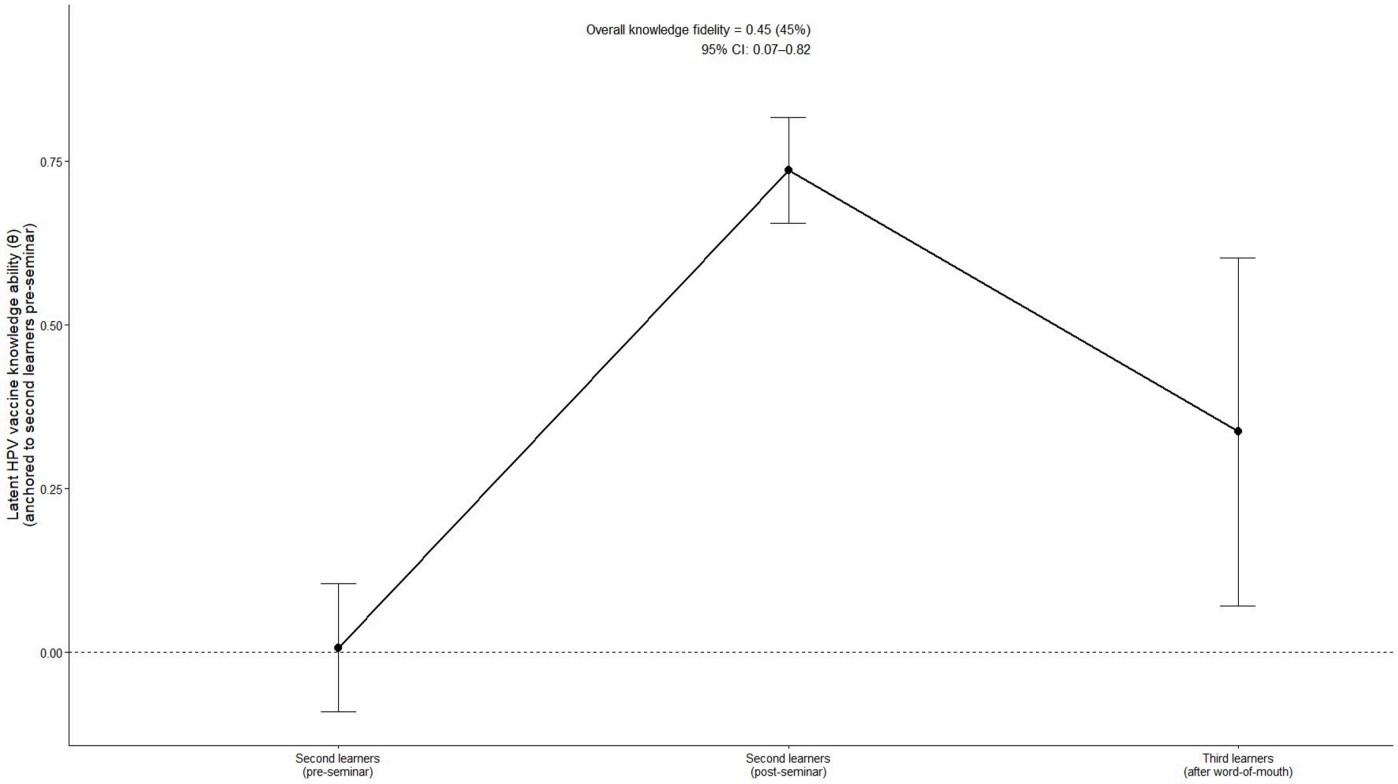

Figure 3

Overall knowledge fidelity during structured word-of-mouth dissemination. Mean latent HPV vaccine knowledge ability (θ) estimated using item response theory is shown for second learners before and after the seminar and for third learners who received the information through word-of-mouth communication. The horizontal dashed line indicates the baseline knowledge level anchored to second learners before the seminar. The fidelity index represents the proportion of seminar-related knowledge gain retained among third learners relative to second learners after the seminar.

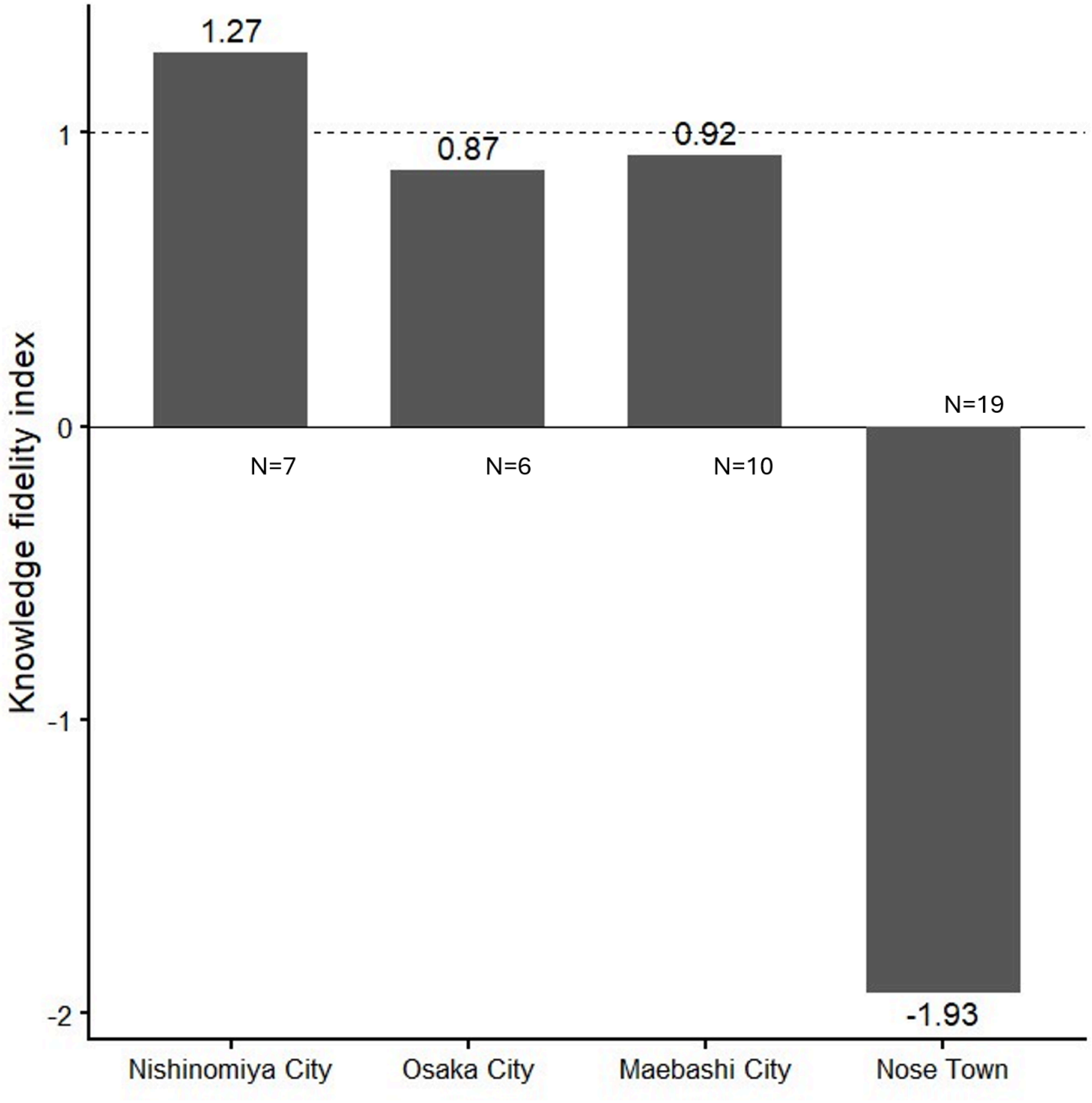

Figure 4

Regional variation in knowledge fidelity during structured word-of-mouth dissemination.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTableS1..xlsx
- Tables.docx