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Social media advertisement for public disease prevention framework as an innovative tool: An approach using EFA and PLS-SEM

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Abstract: The article discusses Social Media Advertisement (SMA) as an innovative tool for Public Disease Prevention (PDP), emphasizing its cost-effectiveness and accessibility to small organizations. The study was applied on 442 Mexican university students in the second semester of 2023 and it aims to highlight the importance of SMA platforms in emerging countries like Mexico and explores their potential as tools for PDP, addressing eight factors. The research follows a four-step methodology involving qualitative and quantitative approaches, leading to the development of a validated questionnaire. The study's theoretical framework integrates qualitative and quantitative methods, offering insights for strategic digital marketing planning, especially benefiting Mexican university students. The research fills a gap in studies related to Mexico and establishes a conceptual framework validated through PLS-SEM, contributing to both theory and practice in SMA for PDP. Future studies are encouraged to explore cross-cultural adaptation and advanced data analytics for a deeper understanding.

Keywords: Social media advertisement, public disease prevention, innovative tool, AHP, exploratory factor analysis, PLS-SEM

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1. Introduction

Social media advertisement (SMA) platforms can potentially public disease prevention (PDP) by fostering citizen engagement, optimizing healthcare systems, serving as an interactive forum for scientific communication, backing health policies, and advocating for healthy practices (Mendoza-Herrera et al., 2020). SMA interventions can impact behaviors and promote PDP actions and lifestyles in several ways. For instance, at the government level actions in the USA, the Infectious Diseases Society of America (IDSA) has revised its strategic plan, focusing on expanding its online visibility and using this platform to establish itself as the foremost and most credible source of infectious disease digital information. This approach encompasses digital tactics such as web utilization, email outreach, social media engagement, mobile accessibility, and other digital channels (Marcelin et al., 2022). Another example is the SMA intervention at the individual level, which can aid them in boosting their perceptions around public diseases based on web attraction, motivations, and attitudes in emergency contexts like COVID-19 (Mejía-Trejo, 2021) and assisting individuals in improving their physical activity and reducing their intake of sugar and fat; it has been achieved through reinforcing motivation among users of online health programs and providing education on nutrition or diabetes (Mendoza-Herrera et al., 2020).

Therefore, the specific aim of this article is twofold: firstly, to offer perspective and insight into the significance of SMA platforms for individuals who have not yet participated actively in emergent countries like Mexico, and secondly, to illustrate the various ways these SMA platforms can be utilized as an innovative PDP tool, relating the customer values, feelings, and irritability. These applications encompass potential actions to enhance a consumer's behavior to avoid being patient, championing specific groups like Mexican university students' perceptions about information with value, personal feelings, and irritability around SMA.

1.1. SMA context

The pervasiveness of SMA is irrefutable, with 72% of adults reporting using at least one social media platform and an average daily usage of 2 hours in the USA (de Vere Hunt & Linos, 2022). Based on the Centers for Disease Control and Prevention projection, over 100,000 lives could be preserved annually if all individuals in the USA underwent clinical preventive services. Preventive healthcare encompasses recognized methods such as monitoring blood pressure, conducting cancer screenings, providing guidance on tobacco use, and administering vaccinations (Merchant, 2020). How we communicate such preventive services has swiftly transformed into a significant portion of SMA interaction. Over 50% of the global population utilizes social media, with an average daily usage surpassing nearly three hours (Chaffey, 2021). Throughout the past five years, the proportion of Americans who acknowledge using social media has maintained a consistent level, hovering around 70% (Auxier & Anderson, 2021). According to a survey by Zocdoc (2023), a Facebook account is held by over half of physicians, while Twitter is used by 21% of them. However, 30% of physicians claim no presence on any social media platform.

According to INEGI (2022), in 2022, 841,318 registered deaths were recorded in Mexico. Of the total deaths, 90.0% were due to diseases and related problems with health, and 10.0% were expected to have external causes (accidents, homicides, and suicides mostly).

Ranking second in terms of social media audience in Latin America and the Caribbean, and eighth globally, Mexico demonstrates a strong reliance on social platforms. With over a hundred million users and significant platform penetration, social networks are widely and frequently utilized, fueling an industry that appears to be a significant substitute for national television viewership and coverage (Statista, 2023). Mexico is home to 94 million social media users in second semester of 2023, representing 73.4 percent of the total population. A total of 123.5 million cellular mobile connections were active in Mexico in early 2023, with this figure equivalent to 96.5% of the total population (Datareportal, 2023). In Mexico, in a 2021 survey of Mexican physicians, WhatsApp emerged as the primary social media platform used professionally by the respondents. Following WhatsApp, around 64% and 47% of those surveyed utilized Facebook and YouTube within their capacity as physicians (Statista, 2021). All those mentioned above represent a real opportunity for the governments and their health systems to save lives and costs by communicating timely public disease prevention measures through the SMA.

1.2. SMA as an innovative tool for prevention diseases: a brief review

To gain a competitive edge, businesses rely on innovation. The SMA has emerged as a new platform for fostering innovation, as consumers increasingly participate in the entire innovation process through Web 2.0 and the edge of Web 3.0 technologies. Firms have effectively used SMA as a valuable tool to shape consumers' attitudes and behaviors. Given the global reach of SMA, it is crucial to recognize cross-border elements when examining the influence dynamics (Chen & Chen, 2016). The SMA presents a chance for professionals in the field of PDP to spread trustworthy safety guidelines. However, there is limited understanding regarding the extent and influence of SMA on public awareness of safety and the adoption of safety practices (McAdams et al., 2021). The SMA denotes internet-based social networking platforms,

representing a wide array of Web 2.0 platforms, including Twitter, YouTube, TikTok, Facebook, Snapchat, Reddit, Instagram, WhatsApp, and various blogs (Mejía-Trejo, 2023).

1.3. SMA and PDP. The state of art

We show in Table 1 some relevant works between 2020 to 2023 relating SMA with PDP and health.

Table 1. Some articles relating SMA-PDP and health framework between 2020-2023.
Source: Own.

Item	Author	Description
1	APA (2023)	Psychological researchers are investigating the potential positive and negative impacts of adolescents' use of the SMA on their social, educational, psychological, and neurological growth.
2	Kanchan and Gaidhane (2023)	SMA constitutes a dynamic and evolving domain. Internet access, SMA platforms, and mobile communication collectively serve as resources that can be utilized to ensure the availability and accessibility of health information.
3	de Vere Hunt and Linos (2022)	Although there is a growing focus on utilizing SMA to distribute public health messages and researching the perils of misinformation on these platforms, there needs to be more detailed information on how public health professionals can proficiently leverage social media to promote health initiatives.
4	Ghahramani et al. (2022)	As a widely utilized and innovative tool for communication and education, SMA provides avenues for altering health-related behaviors.
5	Marcelin et al. (2022)	This article illustrates the extensive influence of SMA in various areas, such as enhancing healthcare and promoting causes, analyzing data, connecting with diverse patient groups, enabling educational opportunities, implementing effective methods in medical teaching, facilitating peer assessment, devising digital plans for individuals and organizations, and countering false information.
6	Abuhashesh et al. (2021)	This study examines the impact of the SMA campaigns, including the specific type of the SMA platform, the type of message, and the sender of the message, on both public health awareness and behavioral modification during the global COVID-19 pandemic in chosen countries: Poland and Jordan.
7	Breza et al. (2021)	Amidst the COVID-19 outbreak, numerous healthcare experts employed the SMA to advocate for preventive health measures.
8	McAdams et al. (2021).	The SMA should combine text corresponding to visuals demonstrating the suggested safety practices to ensure parents comprehend the safety guidelines, irrespective of their eHealth literacy level.
9	Liu (2021)	Amid the COVID-19 pandemic, the SMA has emerged as crucial information conduits capable of positively impacting people's preventive behaviors. Yet, there is limited knowledge regarding the underlying mechanisms that might influence or regulate this relationship.
10	Topf and Wiliams (2021)	The COVID-19 pandemic has led to a deluge of information, a significant portion of which is false or deceptive. Posts on social media containing misleading or harmful viewpoints and analyses are frequently magnified by celebrities and social media influencers, significantly contributing to this surge of information.
11	Al-Dmour et al. (2020)	While there is an increasing amount of research delving into the role of the SMA in healthcare, encompassing areas such as public health communication, promotion, and monitoring, there remains a lack of comprehensive understanding regarding how the effectiveness of the SMA might differ based on the specific public health goals guiding an intervention.
12	González-Padilla & Tortoloero-Blanco (2020)	The SMA platforms have played a pivotal role in the distribution of information. Nevertheless, it is crucial to weigh the various pros and cons associated with their use. Utilizing these tools responsibly can aid in the rapid dissemination of vital new information, pertinent scientific discoveries, sharing of diagnostic, treatment, and follow-up procedures, and facilitate global comparisons, thus eliminating geographical barriers for the first time in history.
13	Mendoza-Herrera et al. (2020)	The SMA serves as a cost-effective resource that can tackle challenges in public health nutrition, particularly in nations where healthcare establishments face financial constraints. It highlights the advantages of leveraging social media to promote documented health benefits as prevention disease measure.
14	Merchant (2020)	The SMA and similar digital platforms facilitating connectivity wield unparalleled impact and are progressively penetrating the realm of healthcare. Unlike healthcare organizations, one distinct advantage of these platforms is their extensive usage across various demographic segments, pervasive among teenagers and young adults. Their positive or negative influence can substantially shape perceptions, behaviors, and decisions about lifestyle.
15	Oh et al. (2021)	Although there has been a growing focus on the impact of the SMA in the context of contagious disease outbreaks, our understanding of how exactly the SMA usage influences risk awareness and preventive actions in these situations still needs to be improved.

Using in all fields= "Social Media Advertisement" and "Public Disease Prevention" in publication years: "2020-2023" in the Web of Science database, were found: 28 documents; with the search within= "article title, abstract, keywords" in Scopus database: 41 documents. Experts consider the results mentioned as emergent trend topics to be developed in an SMA-PDP framework as a strategic approach to effectively reach and engage the public audience. Therefore, our research question is:

What is SMA for the PDP empirical framework as an innovative tool?

2. Materials and methods

As materials, this section aims to determine a conceptual model SMA-PDP (*ex-ante*) based on a qualitative study in this research, applying the Delphi Panel-Focus Group and Analytic Hierarchy Process (AHP) (Saaty, 2008). This procedure involved four specialists: 1 digital marketing expert, 1 digital marketing professor, 1 physician, and 1 university student to determine the main factors involved in the SMA-PDP as a conceptual construct framework. The results are displayed in Table 2.

Table 2. Delphi Panel-Focus Group and AHP. Identification of major factors and indicators of SMA-PPD as the underlying factor. Preliminary questionnaire.
Source: Own.

Names suggested by 1 digital marketing professor (academic vision), 1 digital marketing expert, and 1 university student (user vision)		Priorities suggested by 1 physician (expert vision)
Factors	Indicators based on the perception of: *When I see social media advertisements about public disease prevention (e.g., COVID-19, flu, tobacco exposure, cancer risk, dengue, chikungunya, diarrhea disease, obesity, diabetes, high blood pressure, cholesterol, sexually transmitted diseases, mental diseases, etc.)* in Likert Scale **1-7** (**1.** Strongly disagree; **2.** Disagree; **3.** Somewhat disagree; **4.** Neither agree or disagree; **5.** Somewhat agree; **6.** Agree; **7.** Strongly agree).	AHP Priorities (%) importance
1. AIL	1.I think it is a good source of information.	0.31
	2.I think it provides relevant information.	0.29
	3.I think its information is timely.	0.22
	4.I think to watch a lot of advertising.	0.18
	Total	1.0
2. LIA	5.I think it's irritating.	0.21
	6.I think it's too much advertising.	0.18
	7.I think it insults people's intelligence.	0.17
	8.I think it produces fear.	0.15
	9.I think it produces anger.	0.1
	10.I think it produces sadness.	0.1
	11.I think it produces happiness.	0.09
	Total	1.0
3. ACL	12, I think it is reliable.	0.49
	13.I guess it is credible.	0.35
	14.I think it's convincing.	0.16
	Total	1.0
4. AVL	15.I think it is useful.	0.4
	16.I think it is valuable.	0.35
	17.I think it is important.	0.22
	18.I think it is ethical.	0.03
	Total	1.0

5. ATT	19.I think, it helps me find information that matches my personality and interests.	0.41
	20.I think, it helps me know which brands have the characteristics I am looking for against diseases.	0.29
	21.I think I am willing to be a follower of advertising channel.	0.23
	22.I think it is a good way to learn about diseases and their scope.	0.05
	23.I think I'm open to more publicity about it in the future.	0.02
	Total	1.0
6. MTV	24.I think that increases my general knowledge.	0.28
	25.I think it increases doctor-patient communication.	0.19
	26.I think that is a social support.	0.17
	27.I think that is a source of exchange advice.	0.1
	28.I think it is a source of self-care	0.09
	29.I think it is a source to be updated with new developments in health care.	0.08
	30.I think it is a source of increasing my knowledge about diseases.	0.06
	31.I think it is a source to express my emotions about illness or health	0.02
	32.I think it is a source to compare myself with other patients	0.01
	Total	1.0
7. AFF	33.I think it is a source to share my experience of the disease and its treatment.	0.23
	34.I think it is a source to update others on my current health situation.	0.2
	35.I think it is a source to give advice to other patients/get advice from other patients	0.18
	36.I think it is a source to know news at a global/regional level	0.15
	37.I can identify the misinformation of it myself.	0.12
	38.I can clearly identify the symptoms of diseases.	0.07
	39.I can clearly identify the cure for diseases.	0.04
	40.I can strictly follow the instructions and/or protocols for each disease (e.g., hand washing with soap and water, use of a mask, use of gel, use of sanitizing towels, avoiding public spaces, avoiding areas with mosquitoes, avoiding eating products no hygiene, etc.)	0.01
	Total	1.0
8. LPP	41.It contributes to behavioral changes that protect me as a disease prevention tool for public health.	0.52
	42.It contributes to behavioral changes that protect others as disease prevention for public health.	0.35
	43.It contributes to behavioral changes that educate others as disease prevention for public health.	0.13
	Total	1.0
9. RSK	44.I think it's very serious for me	0.6
	45.I think there is a high probability that I would be affected by them.	0.26
	46. I think that it is very dangerous to be affected by them.	0.14
	Total	1.0

Notes: 1. AIL. Advertising Information; 2. LIA. Irritation Advertising; 3. ACL. Advertising Credibility; 4. AVL. Advertising Value; 5. ATT. Attitude; 6. MTV. Motivation; 7. SEF. Self-Efficacy Perception; 8. LPP. Protection Perception; 9. RSK. Risk Perception.

As research method, this segment outlines the process of assembling and consolidating the datasets for subsequent data analysis, which was conducted in four steps as outlined below:

Step 1. Based on a previous context description, a qualitative study based on the Delphi Panel-Focus Group and Analytic Hierarchy Process (AHP) to determine the preliminary questionnaire SMA-PDP (*ex-ante*), gathering 1 digital marketing expert, 1 digital marketing professor, 1 physician, and 1 university student related to SMA and PDP were questioned about the items and factors related to the preliminary questionnaire design. So far, this step has been resolved, concluding in 46 items distributed in 9 factors (see Table 2).

Step 2. Once all the data in the questionnaires had been collected and were probed regarding the Cronbach Alpha reliability, a quantitative study based on Exploratory Factor Analysis (EFA) was applied, re-grouping the items and factors involved to determine the initial questionnaire (ex-ante)

Step 3. A literature review explained the items and factors for the preliminary and initial questionnaire (*ex-ante*) proposal to be applied to more than 442 Mexican university students in the second semester of 2023.

Step 4. A final quantitative study based on Confirmatory Factor Analysis based on Partial Least Square Structural Equation Modeling (PLS-SEM) was used to probe convergent, discriminant, and nomological validity for the final questionnaire (*ex-post*).

2.1. Demographic data

Based on the results obtained from the frequency analysis of 442 subjects, the most important data of the participants were: 18–29 years old (64.3%); male (55.2%), single (83.3%), bachelor's degree (60.6%), with monthly income less than 9,000 Mexican pesos (45.5%) The results of the frequency demographic data analysis are exhibited in Table 3.

Table 3. Research sample demographic profile.
Source: Own.

Measure	Items	Frequency	Percentage
Age	<18	39	8.8
	18-29	284	64.3
	30-39	72	16.3
	40-49	35	7.9
	50-59	9	2
	>60	3	0.7
Gender	Male	244	55.2
	Female	198	44.8
Marital Status	Single	368	83.3
	Married	74	16.7
Education Level	High School	59	13.3
	Bachelor's Degree	268	60.6
	Master and Doctor Degree	115	26
Monthly Income (Mexican Pesos)	0-9,000	201	45.5
	9,000-16,000	49	11.1
	16,000-21,000	36	8.1
	21,000-27,000	27	6.1
	27,000-32,000	24	5.4
	32,000-39,000	14	3.2
	39,000-47,000	27	6.1
	47,000-59,000	15	3.4
	59,000-78,000	17	3.8
	>78,000	32	7.2

2.2. Sampling based on PLS-SEM technique

The critical discussion for Confirmatory Factor Analysis (CFA) based on PLS-SEM applications' sample size technique involves how large a sample is needed to produce reliable results (Mejía-Trejo & Guzmán, 2018). This decision involves three aspects of framework complexity. According to Hair et al. (2019), the sampling frames could be addressed among:

- Number of constructs. Prior reviews indicate the average number of constructs per model is higher in PLS-SEM (Partial Least Squares-SEM, approximately eight constructs) compared to CB-SEM (Covariance-Based-SEM approximately five constructs)
- Number of indicators per construct. Simultaneously, the number of indicators per construct is typically higher in PLS-SEM than in CB-SEM. In contrast, the PLS-SEM algorithm does not simultaneously compute all the framework relationships but instead uses separate ordinary least squares regressions to estimate the partial regression relationships.

- Number of observations per estimated parameter. Finally, sampling adequacy for this research is based on the number of framework parameters. Minimum sample size of N= 100 to 150 for conducting SEM (Anderson & Gerbing, 1988; Ding et al., 1995; Tabachnick & Fidell, 2001; Tinsley & Tinsley, 1987). Some researchers consider an even larger sample size for SEM, for example, N = 200 (Hoogland & Boomsma 1998; Boomsma & Hoogland, 2001; Kline, 2016). Simulation studies show that with normally distributed indicator variables and no missing data, a reasonable sample size for a simple CFA model is about N = 150 (Muthén & Muthén, 2002). The rule of thumb for multi-group modeling is 100 cases/observations per group (Kline, 2016). Sample size is often considered in light of the number of observed variables. Bentler & Chou (1987) suggest a ratio as low as 5 cases per variable would be sufficient for normally distributed data when latent variables have multiple indicators. Following Hair et al. (2019) again, a basic rule of thumb for sample size is 10 times the number of arrows pointing at a construct, whether as a formative indicator to a construct or a structural path to an endogenous construct. The PLS-SEM algorithm obtains solutions when other methods do not converge or develop inadmissible solutions. In our case 46 indicators X 10 times = 460, with a power analysis =0.8, alpha=.05, number of predictors=9 effect size= medium the resulting sample size= 115 (See Table 4).

Table 4. Sample size based on new rule-of-thumb required to test the hypothesis that population multiple correlations equals zero with the power of 0.80 (Alpha=.05). Source: Belsley (1991), p.503.

Number of predictors	Sampled sizes based on power analysis		
	Effect size		
	Small	Medium	Large
1	400	53	23
2	475	63	27
3	545	73	31
4	610	81	35
5	670	89	38
6	725	97	41
7	775	103	44
8	820	109	47
9	860	115	49
10	895	119	51
15	1045	139	60
20	1195	159	68
30	1495	199	85
40	1795	239	103

The 442>119 Mexican online university students as main users of SMA-PDP sample fulfill this condition widely.

2.3. Data collection

The *"virtual snowball sampling"* method was used in this research; it is a method to recruit participants to access representative samples of interconnected human networks involving consumers with an online user experience. Also, they are very sensitive respondents due to the closed SMA-PDP. Participants (initially 600; finally, 442) were asked to answer the questionnaire created in Table 2 to remind them of their perceptions. They were also provided with a brief description of the concepts dealt with before answering the survey. Participation was voluntary, and confidential; no rewards were provided for participants; it was sent the survey questionnaire via Google Forms from June 16 to December 16, 2023. Therefore, the sample represents online consumer users' perceptions of social media advertisements (SMA) for public disease prevention (PDP).

2.4. The survey instrument

The final survey resulted from the Delphi Panel-focus Group and AHP techniques among four specialists: 1 digital marketing expert, 1 digital marketing professor, 1 physician, and 1 university student related to SMA and PDP. The main question was proposed as a reflective mode, with the sentence: *"When I see social media advertisements about public disease prevention (e.g., COVID-19, flu, tobacco exposure, cancer risk, dengue, chikungunya, diarrhea disease, obesity, diabetes, high blood pressure, cholesterol, sexually transmitted diseases, mental diseases, etc.) I think it is good information…I…"*

The results were posed for each pair of members in 6 rounds (4 subjects in 2 combinations without repetition) according to CombCal (2023). Weighed each round using AHP, the names were suggested by 1 digital marketing professor (*academic vision*), 1 digital marketing expert, and 1 university student (*user vision*). The priorities were suggested by 1 physician (*expert vision*), obtaining the preliminary questionnaire with 9 factors and 46 items. See Table 2.

The preliminary questionnaire was probed regarding the Cronbach Alpha reliability, and with the use of an Exploratory Factor Analysis (EFA), the grouping of the items and factors involved were tested to determine the initial questionnaire (*ex-ante*).

3. Results

This section introduces the results of the Exploratory Factor Analysis (EFA) to determine the initial questionnaire (*ex-ante*) regarding the preliminary questionnaire model with 46 items and 9 factors to obtain the reduction in 8 factors and 38 items (36 useful). Once such a model is attained, the following procedure is to get the discriminant and convergent validation using CFA/PLS-SEM.

3.1. Exploratory factor analysis (EFA)

The Exploratory Factor Analysis (EFA) is a statistical technique to uncover the underlying arrangement within a large collection of variables. EFA is used to reduce data into a more concise collection of variables or factors and delve into the phenomena' underlying theoretical structure. EFA has three basic decision points: (1) decide the number of factors, (2) choose an extraction method, and (3) choose a rotation

method (Mejía-Trejo, 2017). In recent years, EFA has been used for theory development, psychometric instrument development, and data reduction (Norris & Lecavalier, 2009).

Using IBM-SPSS 29 on the results of the preliminary questionnaire within 442 subjects data in 46 items in 9 groups and based on Belsley (1991), who proposes the collinearity diagnosis using the condition index column and the decomposition of variance proportion column with 0.5 criteria as a high proportion threshold so that, finally:

- High condition index (> 30) indicates the number of collinearities, and their magnitude measures their relative importance.
- If a component has a condition index > 30 and two or more nearest variables have a high proportion of variance (> 0.5), those items are collinear.

The result was the withdrawal of 8 items to conform to the initial questionnaire:

12. *I think it is reliable*; 16. *I think it is valuable*; 17. *I think it is important*; 29. *I think it is a source to be updated with new developments in health care*; 30. *I think it is a source of increasing my knowledge about diseases;* 33. *I think it is a source to share my experience of the disease and its treatment*; 41. *It contributes to behavioral changes that protect me as a disease prevention tool for public health*; 42. *It contributes to behavioral changes that protect others as disease prevention for public health*.

Following the procedure of EFA as a factor dimension reduction technique using IBM-SPSS 29 software with extraction method: principal components, method rotation: varimax, we attained 66.812% total variance explained (see Table 5).

Table 5. Total variance explained. Source: Own using IBM-SPSS 29

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.517	30.308	30.308	11.517	30.308	30.308	4.246	11.174	11.174
2	3.649	9.603	39.911	3.649	9.603	39.911	4.070	10.712	21.886
3	3.214	8.458	48.369	3.214	8.458	48.369	3.981	10.477	32.363
4	1.825	4.803	53.172	1.825	4.803	53.172	3.576	9.411	41.773
5	1.517	3.992	57.164	1.517	3.992	57.164	2.553	6.718	48.491
6	1.448	3.811	60.974	1.448	3.811	60.974	2.486	6.541	55.032
7	1.176	3.093	64.068	1.176	3.093	64.068	2.327	6.123	61.155
8	1.043	2.744	66.812	1.043	2.744	66.812	2.150	5.657	66.812
9	.921	2.424	69.236						

With factor analysis that fulfills the requirements KMO=.913 >.7, p<0.01(Hair et al. 2019) and Bartlett's Test (see Table 6).

Table 6. Factor analysis.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.913
Bartlett's Test of Sphericity	Approx. Chi-Square	9217.213
	df	703
	Sig.	<.001

Source: Own using IBM-SPSS 29.

And Cronbach's alpha reliability= .931 (see Table 7).

Table 7. Reliability statistics.

Cronbach's Alpha	N of Items
.915	38

Source: Own using IBM-SPSS 29.

We attained the initial questionnaire with 38 items (36 useful) regrouped in 8 factors (see Table 8).

Table 8. Rotated component matrix sample.

Item	Rotated Component Matrix[a]							
	Component							
	1	2	3	4	5	6	7	8
X1	.803	.092	.120	.104	.056	.039	-.160	.154
X2	.828	.066	.141	.106	.043	.104	-.163	.077
X3	.800	.072	.153	.097	.017	.108	-.214	.165
X4	.446	.052	.149	.093	.364	.022	.033	.097
X5	-.179	-.071	-.113	-.083	.083	-.015	.813	-.042
X6	-.080	-.050	-.119	-.124	.138	-.006	.807	-.052
X7	-.182	-.012	.025	-.236	.394	-.177	.587	.171
X8	.006	.054	.158	.113	.760	.166	.143	-.050
X9	-.039	.139	.107	-.155	.696	-.077	.384	.036
X10	-.002	-.006	.154	.136	.783	.130	.005	-.042
X11	.235	.258	.387	-.204	.226	-.232	.140	.224
X13	.509	.068	.476	.138	-.204	.385	.157	-.014
X14	.517	.032	.369	.190	-.138	.462	.100	.105
X15	.558	.010	.300	.299	-.114	.339	-.045	.105
X18	.547	.089	.263	.161	-.264	.368	-.021	.111
X19	.192	.174	.727	.109	.130	.106	.022	.154
X20	.153	.150	.731	.117	.118	.122	-.099	.172
X21	.158	.205	.763	.041	.220	.062	-.083	.133
X22	.416	.055	.502	.367	.071	.263	-.148	.060
X23	.218	.118	.679	.185	.189	.147	-.257	.042
X24	.185	.164	.132	.793	.064	.072	-.099	.043
X25	.003	.591	.138	.441	-.002	.000	-.005	.181
X26	.067	.473	.189	.608	.001	-.030	-.044	.174
X27	.086	.576	.185	.543	.072	.048	-.071	.090
X28	.173	.147	.093	.803	.012	.126	-.124	.132
X31	.028	.726	.182	.267	.071	.010	-.043	.083
X32	.071	.827	.166	.061	-.013	.002	.017	.096
X34	.049	.831	.038	.069	.062	.158	-.037	-.051
X35	.105	.804	.084	.126	.059	.226	-.052	-.065
X36	.180	.246	-.007	.695	.079	.124	-.157	.051
X37	.150	.048	.109	.157	.048	.033	-.024	.738
X38	.175	.115	.292	.147	-.075	.307	.079	.600
X39	.122	.243	.425	-.189	-.028	.100	.140	.551
X40	.200	-.101	.070	.325	-.031	.275	-.206	.578
X43	.285	.006	.371	.215	-.036	.429	-.227	.279
X44	.279	.251	.368	.179	.182	.453	-.221	.252
X45	.194	.271	.192	.002	.265	.671	-.017	.216
X46	.271	.214	.083	.132	.320	.675	-.100	.191

Notes: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.a a. Rotation converged in 13 iterations.
Source: Own using IBM-SPSS 29

The Identification of major factors and indicators of SMA-PDP after EFA. Initial questionnaire is shown finally, in Table 9.

Table 9. Identification of major factors and indicators of SMA-PDP after EFA. Initial questionnaire (ex-ante). 8 Factors with 38 items.

New names suggested by 1 digital marketing professor (academic vision), 1 digital marketing expert, 1 university student (user vision), and 1 physician (expert vision)		
Factors	Indicators based on the perception of: *When I see social media advertisements about public disease prevention (e.g., COVID-19, flu, tobacco exposure, cancer risk, dengue, chikungunya, diarrhea disease, obesity, diabetes, high blood pressure, cholesterol, sexually transmitted diseases, mental diseases, etc.)…*	Weighed values (From Table 8)
1. CDI	1. I think it is a good source of information.	.803

	2. I think it provides relevant information.	.828
	3. I think its information is timely.	.800
	4. I think to watch a lot of advertising.	.446
	13. I guess it is credible.	.509
	14. I think it is convincing.	.517
	15. I think it is useful.	.558
	18. I think it is ethical.	.547
2. MTV	**25.** I think it increases doctor-patient communication	.591
	27. I think that is a source of exchange advice.	.576
	31. I think it is a source to express my emotions about illness or health	.726
	32. I think it is a source to compare myself with other patients	.827
	34. I think it is a source to update others on my current health situation.	.831
	35. I think it is a source to give advice to other patients/get advice from other patients	.804
3. ENG	**11.** I think it produces happiness.	.387
	19. It helps me find information that matches my personality and interests.	.727
	20. It helps me know which brands have the characteristics I am looking for against diseases.	.731
	21. I think I am willing to be a follower of advertising channel.	.763
	22. I think it is a good way to learn about diseases and their scope.	.502
	23. I think I'm open to more publicity about it in the future.	.679
4. AQK	**24.** I think that increases my general knowledge.	.793
	26. I think that is a social support.	.608
	28. I think it is a source of self-care.	.803
	36. I think it is a source to know news at a global/regional level.	.695
5. EMO	**8.** I think it produces fear.	.760
	9. I think it produces anger.	.696
	10. I think it produces sadness.	.783
6. RSK	**43.** It contributes to behavioral changes that educate others as disease prevention for public health.	.429
	44. I think it's very serious for me.	.453
	45. I think there is a high probability that I would be affected by them.	.671
	46. I think that it is very dangerous to be affected by them.	.675
7. IAD	**5.** I think it's irritating.	.813
	6. I think it's too much advertising.	.807
	7. I think it insults people's intelligence.	.587
8. SEF	**37.** I can identify the misinformation of it myself.	.738
	38. I can clearly identify the symptoms of diseases.	.600
	39. I can clearly identify the cure for diseases.	.551
	40. I can strictly follow the instructions and/or protocols for each disease (e.g., hand washing with soap and water, use of a mask, use of gel, use of sanitizing towels, avoiding public spaces, avoiding areas with mosquitoes, avoiding eating products no hygiene, etc.).	.578

Notes: **1. CDI.** Credibility Information; **2. MTV.** Motivation; **3. ENG.** Engagement; **4. AQK.** Acquisition of Knowledge; **5. EMO.** Emotions; **6. RSK.** Risk Perception;**7. IAD.** Irritation Advertisement; **8. SEF.** Self-efficacy Perception.

3.2. Defining the factors' SMA-PDP model based on EFA

The next step is the definition of each one of the factors related to the initial conceptual model as a result of EFA. These elements are known as the outer model in PLS-SEM too, and they describe the best relationship of how the factors are interacting for a better explanation of the SMA-PDP model, as follows:

3.2.1. Credibility Information (CDI) and Acquisition of Knowledge (AQK)

The CDI plays a crucial role in SMA for PDP by influencing the AQK and promoting health-related behaviors. CDI facilitates health-related research, including surveilling potential public health risks, monitoring public responses to health issues, and disseminating information quickly during disease outbreaks (Chen & Wang, 2021). However, challenges related to the CDI of health information on SMA for PDP exist, as misinformation can harm the adoption as AQK of recommended prevention and control behaviors and decrease support for vital policies, such as vaccination (Kington et al., 2021). Hence, we proposed the following hypothesis:

H1: "Higher CDI Higher AQK"

3.2.2. Credibility Information (CDI) and Irritation Advertisement (IAD)

The IAD related to SMA for PDP impacts the efforts toward accepting the advertisement. High IAD levels have been found to negatively affect the CDI's effectiveness and reduce the overall positive effect of SMA (Sharma et al., 2022). Furthermore, the invasiveness of advertisements can lead to public avoidance of SMA, potentially affecting the reach and impact of health promotion campaigns (Niu et al., 2021). Additionally, several IAD types as intrusive advertisements, which include unwelcomed and irrelevant ads, can upset and turn users off, potentially hindering the effectiveness of public health messages delivered through SMA (Instapage, n.d.). Research on SMA avoidance suggests that perceived ad irritation can lead to public avoidance of personalized advertising (Andrada & Dong, 2019). Hence, we proposed the following hypothesis:

H2: "Higher CDI Lower IAD"

3.2.3. Credibility Information (CDI) and Risk Perception (RSK)

The CDI is decisive in SMA for PDP by influencing RSK. For instance, the role of CDI in the SMA shaping RSK during the COVID-19 pandemic is significant, with the potential to influence preventive behaviors (Tsoy et al., 2021). Using SMA and internet-based data collection for disease surveillance in PDP is promising, but ethical considerations are important (Aiello et al., 2020). Specific characteristics of media content, such as risk precision and self-efficacy information, and sensationalism, can influence RSK and behavioral intentions (Dahlstrom et al., 2012). This is further emphasized by the challenges in discerning genuine CDI in health (Di Sotto & Viviani, 2022). Hence, we proposed the following hypothesis:

H3: "Higher CDI Higher RSK"

3.2.4. Irritation Advertisement (IAD) and Emotions (EMO)

Regarding IAD there are several studies that evidence the importance in SMA for PDP influencing EMO. The heavy IAD effects on EMO, especially negative ones, such as an irritant factor like a product, service, irritant SMA etc., could trigger intensive and aversive responses such as anxiety, which could weaken the effectiveness of the SMA. The level of irritation might be higher if the advertisement is perceived as confusing, deceptive, or annoying (Cuesta-Valiño et al., 2020). For instance, Sansone and Balconi, (2022) found that COVID-19-related ads may promote deeper emotional elaboration, shifting the public attention from the pandemic to the advertisement, but the effect on concrete behavioral intentions was not investigated. Overall, the literature suggests that the effectiveness of SMA for PDP may depend on several factors, such as the emotional engagement elicited by the ad (Zhu, 2022). Hence, we proposed the following hypothesis:

H4: "Higher IAD Higher EMO".

3.2.5. Risk Perception (RSK) and Motivation (MTV)

About the RSK, it is critical in SMA for PDP to influence MTV in preventive behavior. A longitudinal study conducted in the United States and China during the COVID-19 pandemic found that RSK did motivate preventive behavior in the early stages of the pandemic (Li et al., 2022). Similarly, a systematic review of epidemic RSK in highly vulnerable countries found that risk communication interventions during epidemics aim to modify risk perceptions to achieve rapid shifts in MTV population health behaviors. The review highlighted the influence of disease characteristics, such as severity, familiarity, and controllability, on risk perception formation, and the need for further research into the influence of demographic factors on risk perception (Abdelmagid et al., 2022). Hence, we proposed the following hypothesis:

H5: "Higher RSK Higher MTV".

3.2.6. Acquisition of Knowledge (AQK) and Emotions (EMO)

Over the AQK, it has been a topic of interest in SMA for PDP to influence EMO in recent years.

Neuroscientific studies show that messages referring to COVID-19 in SMA are learned and remembered more than other narratives or even the brands, products, or services themselves, with joy being the predominant emotion (Baños-González et al., 2021). SMA use can significantly increase the AQK for preventive behaviors via self-relevant emotions and public risk perception (Oh et al., 2021). Hence, we proposed the following hypothesis:

H6: "Higher AQK Higher EMO"

3.2.7. Motivation (MTV) and Acquisition of Knowledge (AQK)

Regarding MTV, an intricate and diverse process within SMA for PDP impacts AQK. In the context of PDP, understanding the motivations of individuals and AQK is crucial for designing effective SMA campaigns (Mejía-Trejo & Espinoza-Mercado, 2022). For instance, using persuasive technology and user-centered approaches can influence people's motivation through persuasion rather than coercion, which can be valuable in designing social media campaigns aimed at promoting disease-prevention behaviors (Issom et al., 2020). Additionally, it has been highlighted that health messaging works MTV best when is designed in collaboration with the target audience, emphasizing the importance of understanding, based on AQK specific goals and beliefs about disease prevention behaviors (Chater et al., 2023).

Hence, we proposed the following hypothesis:

H7: "Higher MTV Higher AQK"

3.2.8. Emotions (EMO) and Engagement (ENG)

The EMO constitutes a special matter of interest in SMA for PDP to elicit ENG. Graffigna et al. (2020) found that lower engagement levels were associated with higher fears of contagion and vulnerability and lower trust in health authorities. Muis et al. (2022) highlighted the role of emotions in mediating the effects of persuasive messages on preventive behaviors, with negative emotions potentially hindering engagement. However, engaging in these behaviors depends on the perception of the emotions under threat posed by the illness (Lugo-González et al., 2020). Hence, we proposed the following hypothesis:

H8: "Higher EMO Higher ENG".

3.2.9. Self-Efficacy (SEF) and Engagement (ENG)

The SEF is an essential issue in SMA-PDP to generate ENG. Ngai et al. (2020) discuss the potential to engage audiences in public health communication, with the role of medical social influencers in driving engagement. The SEF, in particular, plays a significant role in the ENG to treatment and health behaviors in patients with noncommunicable diseases (Malagris et al., 2020) and patients for chronic disease management enhanced by self-management and behavior change (Bourbeau, 2020). Hence, we proposed the following hypothesis:

H9: "Higher SEF Higher ENG".

3.2.10. Self-Efficacy (SEF) and Motivation (MTV)

Regarding the SEF is an interesting topic in SMA-PDP to create MTV. Research has introduced the concept of social media self-efficacy, which refers to a person's perceived ability to achieve desired outcomes in the context of social media (Hocevar et al., 2014). High SEF can lead to increased motivation, effort, and persistence, while low self-efficacy can result in decreased motivation (Khoa, 2023). Hence, we proposed the following hypothesis:

H10: "Higher SEF Higher MTV"

3.2.11. Motivation (MTV) and Social Media Advertisement for Public Disease Prevention (ZSMAPDP)

MTV represents a clear topic to reinforce the SMA-PDP. The potential of ZSMAPDP is to change individuals' behavior based on motivation MTV for a healthy lifestyle, improve early diagnosis of diseases, facilitate behavior change techniques, and provide social support (Zhang et al., 2020).

MTV is crucial in driving engagement with SMA for public disease prevention because it has substantially altered how individuals seek and share health information, discuss health issues, and engage in health behaviors (Ghahramani et al., 2022). When the SMA aims to motivate the public's intention to change their lifestyles and improve their health, ads should consist of a great deal of text but few graphics with a promotion-focused slogan and content (Lin, 2015).

Hence, we proposed the following hypothesis:

H11: "Higher MTV Higher ZSMAPDP"

3.2.12. Acquisition of Knowledge (AQK) and Social Media Advertisement for Public Disease Prevention (ZSMAPDP)

About the AQK, it is another important factor in SMA for PDP. The AQK and ZSMAPDP are essential components of modern public health strategies, disseminating health information and promoting public health campaigns, with 72% of adults using at least one social media platform and an average daily usage of 2 hours (de Vere Hunt & Linos, 2022). Some examples of how AQK relates to ZSMAPDD include using social media for disease surveillance, professional development, and health promotion (Kanchan & Gaidhane, 2023). Hence, we proposed the following hypothesis:

H12: "Higher AQK Higher ZSMAPPD"

3.2.13. Emotion (EMO) and Social Media Advertisement for Public Disease Prevention (ZSMAPDP)

Regarding the EMO is a very important booster factor in ZSMAPDP because it has mediated notably the relationship between social media use and preventive behaviors during infectious disease outbreaks (Oh et al., 2021). SMA that evoke positive emotions such as hope, joy, and gratitude can also increase engagement and motivation (Tkaczuk et al., 2022). Hence, we proposed the following hypothesis:

H13: "Higher EMO Higher ZSMAPDP"

3.2.14. Engagement (ENG) and Social Media Advertisement for Public Disease Prevention (ZSMAPDP)

Alternatively, the ENG is an interesting factor in ZSMAPDP because it facilitates multi-way conversations and interactions, which are essential for effective public health communication (Heldman et al., 2013). Research has shown that SMA can effectively reach large audiences and indicate the public's sentiment and engagement in disease outbreaks (Strekalova, 2016). For instance, just to mention some relevant cases, during the 2014 Ebola in Western Africa outbreak (Strekalova, 2016), the MERS outbreak in South Korea (Oh et al., 2021; Choi et al., 2017), and the 2020 COVID-19 pandemic (Angawi & Albugmi, 2022; Alrasheed et al., 2022; Sayed et al., 2021) audience engagement with online health information was significantly higher for diseases-related posts, indicating the potential for engagement to reinforce the dissemination of public health information. Hence, we proposed the following hypothesis:

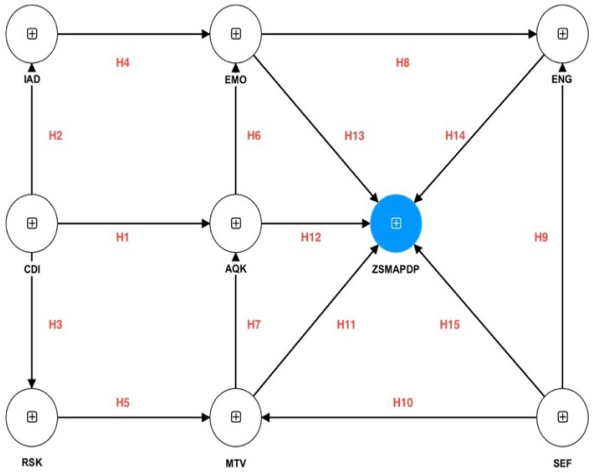
H14: "Higher ENG Higher ZSMAPDP"

3.2.15. Self-Efficacy (SEF) and Social Media Advertisement for Public Disease Prevention (ZSMAPDP)

Finally, the SEF makes a notably topic under study in ZSMAPDP relationship because it refers to the individual's perceived ability to achieve desired outcomes and influence their health attitudes and intentions in the context of social media (Gupta et al., 2022). In the context of public health, leveraging ZSMAPDP to deliver public health campaigns enables the capitalization on SEF by influencing individuals' communicative behaviors on social media channels, which can ultimately affect their health behaviors (Ghahramani et al., 2022). Hence, we proposed the following hypothesis:

H15: "Higher SEF Higher ZSMAPDP"

Thereby, according to the factors and indicators of SMA-PDP after EFA or the initial questionnaire (*ex-ante*) model shown in Figure 1 are related as follows:



Notes: **AQK.** Acquisition of Knowledge; CDI. Credibility Information; **EMO.** Emotions; **ENG.** Engagement.; **IAD.** Irritation Advertisement; **MTV.** Motivation; **RSK.** Risk Perception; **SEF.** Self-efficacy Perception.

Figure 1. The SMA-PPD as ex-ante model. Source: Own using SmartPLS 4.0.9.6

3.3. The CFA/PLS-SEM analysis technique

PLS-SEM (Partial Least Square Structural Equation Modeling) (Wold, 1982; Lohmoller, 1989) is an estimation method based on components, distinguishing itself from conventional covariance-based structural equation modeling (CB-SEM). Unlike the latter, PLS-SEM does not fit a common factor model to the data, opting for a composite model instead (Henseler et al., 2014; Rigdon et al., 2017). By doing this, it aims to maximize the explained variance.

The PLS-SEM consists of two distinct components: the *measurement and structural models*. The outer or *measurement model* depicts the connections between the observed data and the hidden variables, while the inner or *structural model* portrays the associations between these latent variables an iterative algorithm solves the SEM by alternating between estimating the latent variables using the *measurement and structural models*, explaining the name *"partial."* The *measurement model* estimates the latent variables as a weighted combination of their observed counterparts. Meanwhile, the *structural model* estimates the latent variables through either simple or multiple linear regression based on the latent variables previously estimated by the *measurement model.* This process iterates until convergence is achieved (Dijkstra & Henseler, 2015; Henseler et al., 2014; Rigdon et al., 2017). PLS-SEM is an emerging approach to

statistical data analysis, this technique, though recently developed, is experiencing a rapid surge in popularity and finds applications in diverse fields. It has captured the attention of scholars employing diverse methodologies, establishing itself as a dynamic and continually advancing method (Methodspace, 2023). In the contemporary landscape, professionals ranging from corporate and public administration managers to academics and researchers can now access substantial datasets for informed decision-making and exploring novel insights (Becker et al., 2023). PLS-SEM is still considered preferable (over covariance-based structural equation modeling) when it is unknown whether the data's nature is a common factor or composite-based (Sarstedt et al., 2016).

3.3.1. The measurement model internal consistency reliability, significance, and variance assessment as convergent validity

They were computed according to SmartPLS 4.0.9.6 software, with values per factor, of Cronbach´s alpha (>=0.7) (Hair et al., 2023), of rho_A index (>=0.7) (Dijkstra & Hanseler, 2015), of composite reliability index (CRI) (>=0.7), and average extracted variance index (AVE) (>=0.5) (Hair et al., 2023). The indicator's outer loadings should be >0.70. The indicators with values between 0.40-0.70 as outer loadings are for removal only. Such action increases CRI and above the suggested threshold value (Hair et al., 2023). Convergent validity is measured as AVE, which is the grand mean value of the squared loadings of the indicators associated with the construct (Fornell & Larcker, 1981). Therefore, we had to remove X4 and X11 due to the problems with collinearity; to adjust AVE and the measurement model to achieve all the indexes mentioned above. Hence, the SMA-PDP model fulfills the reliability and convergence validity required. See Table 10.

Table 10. The SMA-PDP measurement model internal consistency reliability, significance, and variance assessment as convergent validity. Final questionnaire (*ex-post*) with 8 factors and 38 items (36 useful).
Source: Own using SmartPLS 4.0.9.6

Items	**1.CDI.** Cronbach's alpha (>=0.7)= **0.901**; Dijkstra–Henseler's rho (>=0.7)= **0.904**; CRI (>=0.7= **0.922**; AVE (>=0.5)=**0.628**	Outer loading	*p*Value
1	**X1.** I think it is a good source of information.	0.764	0.000
2	**X2.** I think it provides relevant information.	0.807	0.000
3	**X3.** I think its information is timely.	0.811	0.000
4	**X4.** I think to watch a lot of advertising.	Removed by collinearity issues	
5	**X13.** I guess it is credible.	0.775	0.000
6	**X14.** I think it is convincing.	0.800	0.000
7	**X15.** I think it is useful.	0.803	0.000
8	**X18.** I think it is ethical.	0.787	0.000
	2.MTV. Cronbach's alpha (>=0.7)= **0.883**. ; Dijkstra–Henseler's rho (>=0.7)= **0.890**; CRI (>=0.7= **0.911**; AVE (>=0.5)= **0.630**	Outer loading	*p*Value
9	**X25.** I think it increases doctor-patient communication	0.758	0.000
10	**X27.** I think that is a source of exchange advice.	0.797	0.000
11	**X31.** I think it is a source to express my emotions about illness or health	0.821	0.000
12	**X32.** I think it is a source to compare myself with other patients	0.796	0.000
13	**X34.** I think it is a source to update others on my current health situation.	0.790	0.000
14	**X35.** I think it is a source to give advice to other patients/get advice from other patients	0.798	0.000
	3.ENG. Cronbach's alpha (>=0.7)= **0.873** ; Dijkstra–Henseler's rho (>=0.7)= **0.873** ;CRI (>=0.7= **0.908**; AVE (>=0.5)= **0.663**	Outer loading	*p*Value
15	**X11.** I think it produces happiness.	Removed by low outer loading	
16	**X19.** It helps me find information that matches my personality and interests.	0.801	0.000
17	**X20.** It helps me know which brands have the characteristics I am looking for against diseases.	0.825	0.000
18	**X21.** I think I am willing to be a follower of advertising channel.	0.844	0.000
19	**X22.** I think it is a good way to learn about diseases and their scope.	0.784	0.000
20	**X23.** I think I'm open to more publicity about it in the future.	0.817	0.000
	4.AQK. Cronbach's alpha (>=0.7)= **0.846** ; Dijkstra–Henseler's rho (>=0.7)= **0.847** ;CRI (>=0.7= **0.897** ; AVE (>=0.5)= **0.685**	Outer loading	*p*Value
21	**X24.** I think that increases my general knowledge.	0.855	0.000
22	**X26.** I think that is a social support.	0.758	0.000
23	**X28.** I think it is a source of self-care.	0.856	0.000
24	**X36.** I think it is a source to know news at a global/regional level.	0.814	0.000
	5.EMO. Cronbach's alpha (>=0.7)=**0.823**. ; Dijkstra–Henseler's rho (>=0.7)=**0.856** ;CRI (>=0.7=**0.789** ; AVE (>=0.5)=**0.657**	Outer loading	*p*Value
25	**X8.** I think it produces fear.	0.871	0.000
26	**X9.** I think it produces anger.	0.806	0.000
27	**X10.** I think it produces sadness.	0.836	0.000
	6.RSK. Cronbach's alpha (>=0.7)= **0.831** ; Dijkstra–Henseler's rho (>=0.7)= **0.836** ; CRI (>=0.7= **0.888** ; AVE (>=0.5)= **0.665**	Outer loading	*p*Value
28	**X43.** It contributes to behavioral changes that educate others as disease prevention for public health.	0.729	0.000
29	**X44.** I think it's very serious for me.	0.869	0.000
30	**X45.** I think there is a high probability that I would be affected by them.	0.824	0.000
31	**X46.** I think that it is very dangerous to be affected by them.	0.835	0.000
	7.IAD. Cronbach's alpha (>=0.7)= **0.772** ; Dijkstra–Henseler's rho (>=0.7)= **0.798** ;CRI (>=0.7= **0.865** ; AVE (>=0.5)= **0.681**	Outer loading	*p*Value
32	**X5.** I think it's irritating.	0.818	0.000
33	**X6.** I think it's too much advertising.	0.819	0.000
34	**X7.** I think it insults people's intelligence.	0.839	0.000
	8.SEF. Cronbach's alpha (>=0.7)= **0.719** ; Dijkstra–Henseler's rho (>=0.7)= **0.732** ;CRI (>=0.7= **0.826**; AVE (>=0.5)= **0.544**		
35	**X37.** I can identify the misinformation of it myself.	0.699*	0.000
36	**X38.** I can clearly identify the symptoms of diseases.	0.836	0.000
37	**X39.** I can clearly identify the cure for diseases.	0.721	0.000
38	**X40.** I can strictly follow the instructions and/or protocols for each disease (e.g., hand washing with soap and water, use of a mask, use of gel, use of sanitizing towels, avoiding public spaces, avoiding areas with mosquitoes, avoiding eating products no hygiene, etc.).	0.684*	0.000

3.3.2. The SMA-PDP measurement model discriminant validity

It was computed with SMARTPLS version 4.0.9.6. software. It points to if an underlying factor is measuring a different construct and the degree to which indicators show an example of the target construct. It was calculated according to the traditional discriminant validity assessment method, which requires all relationships between constructs to be less than the lowest of the AVE's square root values (Fornell & Larcker, 1981). See Table 11.

Table 11. SMA-PDP measurement model discriminant and convergent validity.
Source: Own using SmartPLS 4.0.9.6

Fornell and Larcker Criteria (Diagonal= Root Square -AVE-) for discriminant validity HTMT Criteria Ratio<= 0.85<=0.90 for convergent validity									
Factors	1	2	3	4	5	6	7	8	9
1.AQK	0.827	0.485	0.174	0.512	0.388	0.683	0.538	0.476	0.778
2.CDI	0.425	0.793	0.118	0.696	0.389	0.316	0.734	0.646	0.779
3.EMO	0.083	0.017	0.838	0.323	0.415	0.199	0.306	0.155	0.367
4.ENG	0.443	0.618	0.264	0.814	0.275	0.496	0.766	0.649	0.856

5.IAD	-0.314	-0.329	0.342	-0.200	0.825	0.175	0.267	0.224	0.181
6.MTV	0.620	0.287	0.168	0.443	-0.148	0.794	0.503	0.389	0.756
7.RSK	0.456	0.639	0.218	0.658	-0.212	0.439	0.816	0.724	0.875
8.SEF	0.367	0.521	0.083	0.519	-0.100	0.322	0.562	0.738	0.770
9.ZSMAPPD	0.718	0.740	0.328	0.800	-0.152	0.718	0.800	0.655	1.000

Notes: HTMT. It ensures that different constructs capture different concepts. The cut-off value is 0.90 if the constructs are conceptually similar); a more conservative cut-off value is 0.85 (Henseler et al., 2015). Bootstrapping ensures that HTMT results are statistically significantly different from 1.0 because cut-off values have a high likelihood of falsely rejecting discriminant validity and are very conservative (i.e., Type II error) (Franke & Sarstedt, 2019).

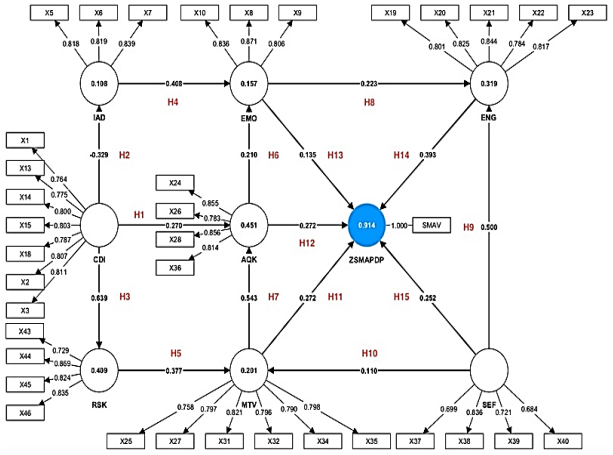
It includes the HeteroTrait-MonoTrait (HTMT) of the relationship criterion as a complement to evaluate discriminant validity. An estimate of what the true correlation between two constructs would be if they were perfectly measured is represented through the HTMT approach is (i.e., when they are perfectly reliable HTMT<=0.85<=0.90) (Henseler et al., 2015; Hair et al., 2023). Hence, the framework fulfills the discriminant validity.

3.3.3. The significance of the structural model relationships

Path coefficients are the hypothesized relationship among the constructs. They are ranged in standardized values between −1 and 1(strongly negative or strongly positive). Values close to 0 are weak relationships. The *p*-values and the f^2 effect sizes dictate the significance of path coefficients used on bootstrapping. It produces a sample distribution approaching the normal distribution; the result is used to establish critical *t-values* (Hair et al., 2019), and subsequently, the *p-values* to discuss the clinical or practical significance (Kraemer et al., 2003). Besides, to modify research conclusions, practical significance involves the magnitude of the observed effect and if it is enough. Therefore, a statistically significant relationship may not be practically significant. Also, some path coefficients might be a very small effect size but are significant; hence, they are essential to drawing appropriate conclusions. There is no consensus, so judgments on the practical significance rely on experts' considerations about measuring practical significance (Kraemer et al., 2003). This way, the significance of the structural model relationships is proved according to the hypotheses following Figure 2. Observe the formative mode of the ZSMAPDP.

3.3.4. SMA-PDP Model´s explanatory power

The coefficient of determination explained variance, or R^2 value, is an essential critical measure in PLS-SEM because it measures the model's explanatory power. By each endogenous construct, R^2 measures the proportion of variance explained. In our case, the factor ZSMAPDP with an R^2 of 0.914 (see Figure 2) means that 91.4% of its variation is explained by all the constructs that point to ZSMAPDPD. Threshold values are not provided because they depend on the model's complexity and the subject matter. Thereby, the adjusted R^2 criterion, is a good practice to consider because it adjusts the R^2 value based on the model size (James et al., 2013). A specific exogenous underlying factor can be assessed if it has a substantial impact on the endogenous ones, using the f^2 effect size (Cohen, 1988). It measures if the exogenous construct has a substantial impact on the endogenous one. Thresholds f^2 effect size values: <0.02 represents no effect; 0.02–0.15 for small effect size; 0.15-0.35 for a medium-sized effect;>0.35 a large effect size was proposed by Cohen (1988). See Table 12.



Notes: AQK. Acquisition of Knowledge; CDI. Credibility Information; EMO. Emotions; ENG. Engagement.; IAD. Irritation Advertisement; MTV. Motivation; RSK. Risk Perception; SEF. Self-efficacy Perception.

Figure 2. The SMA-PDP Framework proposal for path coefficients, coefficient of determination (R^2) and hypotheses.
Source: Own using SmartPLS 4.0.9.6.

Table 12. SMAPDP Structural Measurement Model and Hypotheses tests.
Source: Own using SmartPLS 4.0.9.6

Hypotheses	Paths	Path [*t-value; p-value*]	Result	5%-95% Confidence Interval	Interval Result (Crossing 0?)	f^2 Effect Size	
						I	E
H1: "Higher CDI Higher AQK"	CDI -> AQK	0.270 [6.686; 0.000]	A	[0.203; 0.334]	No	0.122	S
H2: "Higher CDI Lower IAD"	CDI-> IAD	-0.329 [5.923; 0.000]	A	[-0.421; -0.238]	No	0.121	S
H3: "Higher CDI Higher RSK"	CDI-> RSK	0.639 [21.133; 0.000]	A	[0.589; 0.689]	No	0.691	L
H4: "Higher IAD Higher EMO"	IAD-> EMO	0.408 [6.984; 0.000]	A	[0.308; 0.500]	No	0.178	M
H5: "Higher RSK Higher MTV"	RSK-> MTV	0.377 [7.271; 0.000]	A	[0.292; 0.462]	No	0.122	S
H6: "Higher AQK Higher EMO"	AQK-> EMO	0.210 [4.556; 0.000]	A	[0.136; 0.286]	No	0.047	S
H7: "Higher MTV Higher AQK"	MTV -> AQK	0.543 [15.944; 0.000]	A	[0.486; 0.598]	No	0.492	L

H8: "Higher EMO Higher ENG"	EMO-> ENG	0.223 [5.622; 0.000]	A	[0.157; 0.289]	No	0.072	S
H9: "Higher SEF Higher ENG"	SEF-> ENG	0.500 [12.685; 0.000]	A	[0.434; 0.563]	No	0.365	L
H10: "Higher SEF Higher MTV"	SEF-> MTV	0.110 [2.407; 0.020]	A	[0.021; 0.199]	No	0.010	S
H11: "Higher MTV Higher ZSMAPDP"	MTV-> ZSMAP DP	0.272 [12.699; 0.000]	A	[0.236; 0.305]	No	0.495	L
H12: "Higher AQK Higher ZSMAPDP"	AQK-> ZSMAP DP	0.272 [12.730; 0.000]	A	[0.237; 0.307]	No	0.489	L
H13: "Higher EMO Higher ZSMAPDP"	EMO-> ZSMAP DP	0.135 [8.404; 0.000]	A	[0.108: 0.160]	No	0.194	M
H14: "Higher ENG Higher ZSMAPDP"	ENG-> ZSMAP DP	0.393 [18.972; 0.000]	A	[0.359; 0.427]	No	1.073	L
H15: "Higher SEF Higher ZSMAPDP"	SEF-> ZSMAP DP	0.252 [13.079; 0.000]	A	[0.220; 0.284]	No	0.522	L
Q^2 Predict Model PLS-SEM with LM							
Independent Variable	Q^2>0	PLS-SEM RMSE	PLS-SEM MAE	LM-RMSE	LM-MAE	PLS-SEM - LM RMSE	P
ZSMDPDP	0.529	0.595	0.474	0.527	0.417	0.068	H

Notes: NA. Not Applicable **I. Interval**=0.02<=0.15<=0.35. **Effect: S.** Small; **M.** Medium; **L.**Large) **P.** PLS-SEM Prediction Error (Descriptives) Skewness

H. Highly predictive model One-tailed *t-values* and *p-values* in parentheses; bootstrapping 95% confidence intervals (based on n= 5000 subsamples) SRMR: standardized root mean squared residual; dULS: unweighted least squares discrepancy; dG: geodesic discrepancy; HI99: bootstrap-based99% percentiles.

f^2. Effect size. 0.02, 0.15, and 0.35 are interpreted as small, medium, and large (Cohen, 1988)

R^2. Coefficients of determination represent the amount of explained variance of the endogenous constructs in the structural model. Therefore, values of 0.25, 0.50, 0.75 for target constructs are considered as weak, medium, and substantial, respectively (Hair et al. 2019)

SRMR. The Standardized Root Mean Square Residuals are a common fit measure for CB-SEM (Henseler et al., 2015). Detection is also used for misspecification of PLS-SEM models (Henseler et al., 2014). Besides, it includes the following fit measures: squared Euclidean distance (dULS) and the geodesic distance (dG) (Dijkstra & Henseler, 2015)

Result. A. Approved; R. Rejected

Q^2 Predictive Indicator must be >0 in an independent variable; MAE. Mean Absolute Error; RMSE. Root Mean Squared Error. If prediction errors are highly symmetrically distributed, use RMSE; if not, use MAE. In our case, the skewness is based on RMSE, where only 2/38 indicators were asymmetrically distributed. Thereby, the SMA-PDP is a highly predictive model (Shmueli et al., 2016)

3.4. Discussion

In the domain of social media advertising (SMA) for public disease prevention (PDP), a unified story emerges, intertwining the intricate connections among multiple elements—namely, credibility information (CDI), irritation advertisement (IAD), risk perception (RSK), acquisition of knowledge (AQK), motivation (MTV), emotions (EMO), engagement (ENG), and self-efficacy (SEF) as strategical factors of digital marketing planning. Hence, we attained two main contributions.

3.4.1. Theoretical implications

The theoretical contribution of the described research approach is multi-faceted, combining all the elements of digital marketing mentioned above with qualitative and quantitative methods to develop and validate a questionnaire related to social media advertisement (SMA) as a very strong tool for public disease prevention (PDP). Hence, the main theoretical contributions are based on its own methodology, as follows:

- Integration of a qualitative method. The use of the Delphi Panel-Focus Group and Analytic Hierarchy Process (AHP) as a qualitative method allows expert inputs and consensus-building. This method helps generate a preliminary questionnaire by tapping into the diverse perspectives from four expert's points of view: a digital marketing expert, a digital marketing professor, a physician, and a university student. As a preliminary questionnaire, there were 46 indicators in 9 factors (or groups).
- Targeting a specific population focused on 442 Mexican university students in the second semester of 2023. This specificity adds practical value by tailoring the design of the questionnaire to this population's cultural and contextual nuances, potentially yielding more accurate and applicable results related to academic knowledge.
- Exploratory Factor Analysis (EFA). Applying EFA in the quantitative phase aids in the dimension reduction to identifying underlying factors and re-grouping items based on statistical relationships. The qualitative insights were obtained in the Delphi Panel-Focus Group-AHP with a more systematic data exploration. This procedure allowed us to preserve the original item as much as possible to attain 38 items (36 useful) in 8 factors (or groups) as an initial questionnaire (*ex-ante*).
- Contextualization through Literature Review. Including a literature review enhances the theoretical foundation of the questionnaire design. By connecting the items and factors proposed in the questionnaire to existing literature, the study contributes to a deeper understanding of the theoretical framework underpinning SMA and PDP among Mexican university students.
- Questionnaire Development and Validation based on Cronbach Alpha Reliability. The use of Cronbach Alpha reliability analysis ensures the internal consistency of the questionnaire items. This step is crucial in establishing the instrument's reliability developed through the Delphi Panel-Focus Group and AHP process.
- Confirmatory Factor Analysis (CFA) based on or the application of Confirmatory Factor Analysis based on Partial Least Square Structural Equation Modeling (PLS-SEM) in the final phase is a robust method for validating the construct validity of the questionnaire. This includes a final questionnaire (*ex-post*) with 36 items in 8 factors x (or groups) testing for convergent, discriminant, and nomological validity, ensuring that the instrument measures what it intends to measure.

As we see, the 15 (fifteen) hypotheses were approved, highlighting the H2: *"Higher CDI Lower IAD"*, where despite the annoying of an advertisement, the credibility information

counteracts effectively, although its effect size is small. Also, we have the case of H10: *"Higher SEF Higher MTV,"* where despite self-efficacy being higher, the motivation interacts similarly, although the effect size is very small. The positive correlation between the rest of the hypotheses points to the specialist in marketing and professionals or authorities in health reinforcing such factors, whether they are with effect size small or medium. The hypotheses with large effect sizes can be kept equal.

3.4.2. Practical implications

The practical contributions of the described research approach are significant and can have tangible implications for various stakeholders. Here are the practical contributions:

- Tailored Intervention from strategic 8 factors as digital marketing planning integrated into a social media advertisement (SMA) for public disease prevention (PDP). These 8 elements help to achieve more effective, efficient, and assertive communication between the public and the sanitary authority, the health professionals, policymakers, and organizations involved in public health interventions.
- The tailored nature of the questionnaire ensures that the strategies derived from it are specifically designed for a specific context, like the Mexican university students, adding practical value.
- The results and insights gained from this specific population can be directly applied to educational programs and campaigns aimed at disease prevention among university students in Mexico. This targeted approach increases the relevance and effectiveness of interventions.
- Practically, this informs decision-makers in the field of digital marketing, allowing them to align their strategies with established theoretical frameworks. Health communication specialists and digital marketers can use this information to design more effective campaigns for disease prevention.
- The rigorous reliability and validation process, including Cronbach Alpha reliability analysis and Confirmatory Factor Analysis based on Partial Least Square Structural Equation Modeling (PLS-SEM), ensures that the developed questionnaire is a reliable and valid instrument. Practically, this means that organizations, researchers, and policymakers can confidently use the questionnaire to assess the impact of social media advertisement (SMA) on disease prevention, making informed decisions based on robust data in Mexico and other countries like this.

4. Conclusion

In conclusion, the research conducted on social media advertisement (SMA) for public disease prevention (PDP) yields significant theoretical and practical contributions solving the main question about what the SMA for PDP conceptual framework as an innovative tool is.

The theoretical implications highlight a comprehensive methodological approach integrating qualitative and quantitative methods. Delphi Panel-Focus Group, Analytic Hierarchy Process (AHP), Exploratory Factor Analysis (EFA), and a thorough literature review contribute to developing and validating a questionnaire with 38 items (36 useful) in 8 factors. The contextualization through a literature review further enhances the study's theoretical contributions, ensuring a solid theoretical foundation. The application of Confirmatory Factor Analysis (CFA) based on Partial Least Square Structural Equation Modeling (PLS-SEM) validates the construct validity of the questionnaire, affirming its reliability through Cronbach Alpha analysis.

In terms of practical implications, the research offers tailored interventions based on the identified 8 factors for digital marketing planning in SMA for PDP. These interventions facilitate more effective communication between the public and various stakeholders, including sanitary authorities, health professionals, policymakers, and organizations involved in public health interventions.

The specificity of the questionnaire, tailored to Mexican university students, adds practical value by providing insights directly applicable to educational programs and campaigns aimed at disease prevention in this demographic. Decision-makers in digital marketing can align their strategies with established theoretical frameworks, and health communication specialists can design more effective campaigns for disease prevention.

The rigorous reliability and validation process ensures that the developed questionnaire is a reliable and valid instrument. This practical aspect allows organizations, researchers, and policymakers to confidently use the questionnaire to assess the impact of SMA for PDP, making informed decisions based on robust data in Mexico and potentially in similar contexts globally.

Future studies can further enrich the understanding of SMA for PDP, extending the research's impact and applicability across diverse contexts and over extended periods and might be include:

- Cross-Cultural Adaptation and Validation. Explore the applicability of the developed questionnaire and identify factors in different cultural settings. Conduct cross-cultural studies to understand how cultural nuances may influence the effectiveness of SMA for PDP. This could involve adapting the questionnaire for diverse populations and assessing the generalizability of the identified factors and their relationships.
- Longitudinal Impact Assessment: Undertake longitudinal studies to track the long-term impact of SMA strategies for PDP regarding the framework attained. Assess how

changes in ENG, EMO, and AQK persist over time, for instance, providing insights into the sustainability of the identified factors and their effectiveness in the dynamic landscape of social media.

- Incorporating Advanced Data Analytics. Explore the integration of advanced data analytics techniques, such as machine learning and predictive modeling, to enhance the predictive power of SMA strategies. Investigate how real-time data analysis can inform adaptive advertising campaigns and improve the overall effectiveness of public disease prevention efforts on social media platforms.

Overall, this research advances our understanding of the intricate connections among various elements in the realm of SMA for PDP and provides actionable insights for improving public health communication strategies through social media.

Conflict of interest

The author has no conflict of interest to declare.

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