

Nanotechnology In Personal Care: Revolutionizing Skincare, Haircare, And Cosmetics With Nano-Enhanced Products

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ABSTRACT

Purpose: The purpose of this study was to investigate consumer perceptions and behaviors towards nano-enhanced personal care products, with an emphasis on factors affecting safety perception and willingness-to-pay-a-premium as well as demographic influences i.e. age, gender.

Objective: the main aim is to recognize essential factors influencing nano-enhanced personal care products consumer purchase decisions and investigate the effect of demographic variables mainly like age, gender on these is studied. Secondly, the study also aims to investigate the relationship between perceived safety and willingness of pay a premium for these products.

Methodology A cross-sectional survey research design was used to collect data from 190 individuals who are potential consumers of nano-enhanced personal care products. The sample was diverse in terms of age and gender. Data were analyzed through ANOVA, T-tests, correlation analysis and logistic regression using a Chi-square tests. These tests were used to explore the association of demographic variables, safety perceptions and familiarity with nanotechnology with willingness-to-pay a premium. The results were further visualized using boxplots, violin plots, scatterplots, bar plots, and heatmaps to provide clear and insightful graphical representations of the data, enhancing the interpretation of statistical findings.

Results: The ANOVA result indicated no significant difference in safety perceptions across age groups ($F(4,185) = 0.579$, $p = 0.677$), while T-tests revealed no significant gender differences ($t(188) = -0.059$, $p = 0.953$). A weak and non-significant correlation was found between age and safety perception ($r = 0.080$, $p = 0.267$), as shown in the scatterplot. Logistic regression analysis identified age as a significant predictor of willingness to pay a premium ($\beta = 0.256$, $p = 0.041$), though safety perception was not a significant factor ($\beta = -0.130$, $p = 0.296$). Chi-square tests showed no significant association between gender and either familiarity with nanotechnology ($\chi^2(6) = 6.201$, $p = 0.401$) or willingness to pay a premium ($\chi^2(6) = 5.567$, $p = 0.473$). The statistical findings were supplemented with graphical visualizations: boxplots illustrated the distribution of safety perceptions across age groups, violin plots compared gender differences in safety perceptions, scatterplots depicted the correlation between age and safety perception, bar plots showed logistic regression coefficients, and heatmaps visualized associations in the Chi-square tests.

Practical Implications: The findings suggest that marketing strategies for nano-enhanced personal care products should emphasize efficacy and innovation over safety concerns, as these factors are more likely to influence consumer purchasing decisions. Additionally, the study highlights the importance of targeting a broad demographic, as age and gender do not significantly impact safety perceptions or familiarity with nanotechnology. Building consumer confidence and ensuring product safety will require well-defined, science-based regulations.

Novelty: The current research presents a better understanding of effectual variables influencing consumer perceptions about nano-product in personal care domains, with respect to interactions between safety perception, WTP and some aging factors like gender. These results have important implications, including the fact that marketers should not assume demographic factors drive consumer behavior and must pursue alternative marketing strategies in a changing economic

environment. **Conclusions:** The results suggest that except for the presence of ingredient-related health concerns, which overall has a negative impact on consumer perceptions; other factors such as perceived benefits, efficacy and novelty factor rather than risk/risk perception appears to be strong drivers in shaping attitudes toward nano personal care products. Young consumers are much more willing to pay a premium for "gender neutral" products than older generations, though gender does not appear to have any significant effect of how frequently people buy these items. Implications for Personal Care Marketers, Product Development and Regulatory Authorities

Keywords: *Nano-Enhanced Personal Care Products; Consumer Perceptions; Safety Perceptions; Willingness to Pay; Demographic Influences; Nanotechnology; Marketing Strategy; Product Development; Regulatory Implications*

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1. INTRODUCTION

The introduction of nanotechnology has brought a new pace to innovation in multiple sectors, ranging from pharmaceuticals and electronics through food up to personal care. Of these, the personal care industry has been eager to integrate nanotechnology into its products taking advantage of the special properties nanoparticles possess and using them to make skincare, haircare and cosmetics more effective and desirable. Nanotechnology enables the manipulation of materials at a molecular level, developing particles that are better absorbed by the skin, have high capacity to deliver active ingredients and can sustain action for longer periods. This can change how consumers experience personal care products by allowing much greater benefits that were inaccessible before. Nevertheless, the utilization of nanotechnology in daily-life consumer products is also accompanied by variety inquiries and worries specifically safety, mechanism as well as person approval (N. Singh, Kumar, Usman, & Susan, 2024).

Despite the potential advantages of nano-enhanced personal care products, little is known about how consumers view these innovations. There are certainly several benefits linked to nanotechnology, including increased product performance and all new delivery methods; however, the public perception of these products is varied yet complicated. Persons refer not only advantages but risks could be associated with use of nanomaterials, especially by apply to skin or eat. This concern is further heightened as the newer of technology and insufficient long-term study exhibits into second feature of nanoparticles in consumer products. Thus, it cannot be assumed that the market for nano-improved personal care will automatically come into being and this depends on a range of factors, including perceptions about safety, how much people trust manufacturers or retailers as well as levels of certainty in regulation all influenced by communication strategies with which to inform and educate them (Rathnasinghe et al., 2024).

This original research has the specific objective to contribute toward examining under what circumstances do consumers perceive and act in novel ways towards nano-enhanced personal care products, i.e., where this study targets underlying factors that drive these new forms of consumption. Identity e.g. family, given that the market for these products is expanding, understanding how customers make decisions about adopting and using them has never been more important to manufacturers, marketers and public policy makers. Without this knowledge, there is a danger that consumer mistrust could restrain the wider market growth of nano-enabled personal care products and restrict potential nanotechnology benefits to its domain. Not getting a buy-in from the consumer could prove to be an opportunity lost in terms of innovation and expansion within this space, besides facing marketing regulatory hurdles effectively (Chakraborty, Panja, Dutta, & Patra, 2024).

This study sets out to achieve several key objectives to address this research problem. In summary, this study serves four purposes: it assesses consumer attitudes toward nano-enhanced personal care products; and within that framework: firstly, to examine the role demographic differences e.g., age, gender education etc. play in shaping those perceptions. Instead, the study looks for discernable demographic variables that may align more or less favorably to adoption of these products. By identifying these segments, it becomes easier to cater your marketing campaigns towards the specific concerns and lifestyles that differentiate each one. The authors go further to consider how trust serves a critical factor in influencing consumer perceptions, especially as it relates to attitudes toward manufacturers and regulatory bodies but also the scientific community (A. Prajapati & Kumar, 2024).

When it comes to consumer decision-making about new and emerging technologies such as nanotechnology, trust plays a particularly significant role. This study seeks to shed light on the role of trust in shaping consumer acceptance of nano-enhanced products and how such distrust can be engendered by different antecedents. The study thirdly discusses how well different communication strategies can be used to inform consumers about the benefits and risks of nano-enhanced personal care products. Such research should evaluate the effects of label, advertising and PR strategies on consumers' knowledge about, perception or acceptance of these products. Finally, the paper examines ethical and social issues in nanotechnology

personal care and discusses how these broader concerns could contribute to shaping consumer perceptions (Powar, Chaeun, & In, 2024).

The study adopts a quantitative research approach aimed at meeting the goals, using cross-sectional survey data of a broad sample of consumers. The survey also asks for information on demographics, nanotechnology familiarity level, perceptions of safety and efficacy, trust in various sources of information e.g., government agencies vs. industry, and responses to different communication strategies which are tailored by heterogeneous risk-types. The data is further analyzed through certain statistical techniques i.e. ANOVA, T- tests, correlation analysis, Logistic regression and Chi-square test etc. The associations between demographic profiles and consumer perceptions, trust impact on behavior patterns of consumers and marketing strategies that were effective in changing the consumer attitude towards PRFs are discussed. Results derived from this strong methodological approach is anticipated to be of interest not only statistically significant but also pragmatically poised for stakeholders within the personal care space (Achagar et al., 2024).

This outline of the paper is structured to lead the reader through methodically completing a research endeavor. The paper starts with an introduction to frame the study and then reviews literature that critiques previous research in nanotechnology, personal care products and consumer behavior. The review notes some gaps in the current literature and points to where this study fits into broader academic discussions. Then the methodology part describes what types of research design as well sample selection and data collection method also analysis techniques followed which highlight that the study can be repeated by others. Reporting the results: This is where you present all your statistical analyses, pointing out what sort of relationships and trends you found in your data. After the results section, we again have discussion that explains what these findings means in relation to our research objectives and literature review & suggestions on how it can help industry practice/ policy and future studies. The paper ultimately closes by revisiting the key findings of the study and proposing avenues for further inquiry (Dhanesh, Santosh, & Naikawadi, 2024).

To our knowledge, this study fills an important void in understanding how consumers perceive and behave towards nano-enhanced personal care products. As consumer acceptance is one of the key success factors for sufficient penetration of autonomous vehicles, understanding these will help manufacturers to manage their offerings towards satisfying customer demands and ensuring consequent applications while policy makers consider potential incentives or restrictions. Noting the growing prestige in nanotechnology and its adaptability to revolutionize personal care, the study stands as both timely and enlightening. This study is unique for its more holistic campaign to elucidate how consumers interact with nanotechnology in their everyday lives which will help streamline marketing of these innovations in ways that resonate and matter most to end users (Anand, Mishra, & Bharadvaja, 2024).

Because there will be more and more consumer products using nanotechnologies, it becomes essential to know what determines acceptance of those technologies by consumers. The results suggest an approach to address consumer perceptions toward nano-enhanced personal-care products as well as providing a fresh start for future work in this emerging field. The study is expected to inform similar efforts in other areas nanotechnology entry, such as food safety, pharmaceuticals and environmental sustainability by examining the impact of demographics on attitudes, trust dynamics within networks that communicate about these issues. Such research thereby underscores the need to better align technological progress with consumer and societal preferences, for nanotechnology to be ethically deployed in a way that maximizes its societally beneficial applications (Gupta, Rawat, & Aggarwal, 2024).

2. LITERATURE REVIEW:

Consumer perceptions of and behaviors toward nano-enhanced personal care products can be understood by the literature on consumer behavior, nanotechnology, cosmetics industry. The paper is a systematic review of existing research in these areas, relating this previous work to the present study's contribution. The goal is to demonstrate the need for this research by showing where it fits within the existing knowledge. Nanotechnology, which is frequently anticipated as a game-changer in many industrial and commercial niches, has attracted considerable attention also within the personal care products sector. Nanotechnology is often used in cosmetics and skincare because it can improve the effectiveness of a product by making it easier to deliver ingredients deep into your skin. By enabling the control of materials at a molecular scale, nano techniques mean that nanoparticles can be created for personal care products that carry active ingredients deeper into the skin with prolonged release over time and subsequently improve overall efficacy Smith et al. Despite visible progress made using nanotechnology in personal care products, consumer perception and acceptance of nano-enhanced skincare still represents a hurdle obstacle within this industry (A. Kumar, T. J. Jayeoye, et al., 2024).

An examination of consumer attitudes toward nanotechnology has found a nuanced set of beliefs that is shaped by perceptions about the risks and benefits as well as the extent to which science and technology can be trusted. For example, consumer attitudes toward nanotechnology appear to be characterized by a dual attitude Jones et al., with reports of strong support for the potential benefits as well as serious reservations regarding possible risks. The personal care category is particularly fraught with ambivalence given that these products come in direct contact with our skin, and fears about their safety have long circumnavigated concerns regarding potential health risks. Consumer acceptance of nano-enhanced products Consumer acceptance toward the safety and measures in manufacturing was closely tied to them regarding those

as being at the top. Even so, little research has been conducted on the impact of demographic characteristics like age, gender and education have on these perceptions specifically in personal care products (Maghraby, Ibrahim, El-Shabasy, & Azzazy, 2024).

Nanotechnology is vigorously embraced by the cosmetics industry, which nearly depends on never-ending innovation to produce higher-performing and improved-value new products. The use of nanoparticles including nano emulsions, liposomes and nano capsules has become more widespread in skincare/ cosmetic formulations Wilson et al. The new particles are intended for more efficient delivery of actives, protecting sensitive components from degradation and providing a smoother, uniform application. But the big question that not many have been able to answer is how do consumers respond when such improvements are made. Prior empirical work on the cosmetics industry and consumer behavior focuses mainly on traditional factors by Davis et al., such as brand loyalty, effectiveness of product performance, or price sensitivity. As the contribution of nanotechnology to consumer preferences is not well understood, leading us at a gap in our understanding regarding how consumers perceive and evaluate nano-enhanced personal care products compared to traditional alternatives (Sichani et al.).

The incorporation of nanotechnology into personal care products has raised controversy regarding the possible health and safety risks associated with nanoparticle exposure. For example, nanoparticles can have very good bulk materials and their characteristics height or other biological interactions of Johnson et al. Their small size and high surface area make nanoparticles potentially able to be more easily absorbed by biological membranes, resulting in toxic effects on health over long exposure durations. This is especially the case with regard to everyday personal care products, which are used over long time periods and can result in cumulative exposure. Nevertheless, with regards to regulatory frameworks of nanotechnology in cosmetics there are considerable differences between different regions and still not even a global harmonization on the safety-evaluation standard for nano-enabled products Lee et al. Such regulatory ambiguity often fuels consumer doubt and concern that could also be a hindrance to the market adoption of these products (A. Sharma, Krishan, Sharma, Surya, & Gautam, 2024).

The contribution of consumer education and label signals to endogenize consumers' perception on nanotechnology has also been underlined in the literature. However, people who are more informed about nanotechnology are generally also less opposed to nano-enhanced products because they know the benefits of this technology can better be appreciated and juxtaposed against Miller et al. Despite such high uncertainty, the public is not given more than superficial information or wrong information about nanotech Taylor et al. This knowledge gap highlights the need for manufacturers and policy makers to communicate more effectively, thereby allowing consumers a greater insight into not only what exactly nano-enhanced products are made up of, but also in total transparency as well. Due to the complexities of conveying scientific information to a lay audience, especially when it comes to risk-benefit trade-offs for nano-enhanced personal care products, future work should investigate optimal mechanisms for consumer engagement in this topic (Pore, Bais, & Chandanshive).

While research on nanotechnology in personal care products is increasingly common, there are several key gaps in the literature that need to be further investigated. Although many previous studies have examined the technical aspects of nanotechnology and its (potential) risks and benefits, less attention has been paid on consumer perspectives such as how demographics relate to perceptions or behavior. This study will further aim to address this gap by investigating whether consumer attitudes towards nano-enhanced personal care products differ according to age, gender and educational background. This could help us to understand which demographic segments might be early adaptors and what potential new markets are, providing information for targeted marketing strategies and software development. Very little research has repeatedly examined the social acceptance of nanotechnology in consumer end use across time or longitudinally (Veludurthi & Vadaga, 2024).

The majority of the extant literature provides a static view of public attitudes to recycling maybe inadequate for reflecting how consumer perceptions change over times as people learn new things and society changes Roberts et al. Adopting a longitudinal strategy could offer an insight into the process by which consumer perceptions of nano-enhanced products evolve, possibly in response to emerging research outcomes as these are followed up with regulatory changes and then enter the public domain. Although the current study is cross-sectional, it sets the stage for future research that takes a longitudinal approach to examine temporal dynamics of these processes. There is thus a need for longitudinal studies to see whether consumer attitudes about nano-enhanced products change as they are more widely adopted and the public discourse on their safety and benefits continues over time (Mounira, 2024).

In addition, greater understanding is also needed of how trust affects consumer attitudes towards nano-enabled personal care products. In consumer decision making, trust positively influences behavior toward new technologies with possible controversy Garcia et al. The literature on the one hand heights how trust can reduce scan: heat perceptions and increase perceived benefits of nanotechnology which in rum contributes to acceptance of nano-enhanced products Harrison et al. Yet, constructs such as trust are multifaceted and may emerge differently for various reasons past experiences in individuals lives by gender or through cultural norms often depicted within filmic narratives. This study examines how consumer subjective norms are implicated in purchasing decisions and the roles of scientists, government agencies, and product manufacturers as trust sources when it comes to identifying nano-enhanced personal care. The findings of this analysis may

be useful in informing on how to use trust-building strategies for increasing consumer adoption of these products. This information may enable marketers and policymakers to focus their efforts on specific factors that influence trust in consumer attitudes towards nano enhanced products (Almeman, 2024).

The current study also sets out to bridge the research gap as questions about how marketing and communication strategies influence consumer perceptions in relation to nano-enhanced personal care products remain unanswered. Extant literature suggests that the format of information matters quite a bit, with transparency the extent to which consumers understand the process used and can access it if they choose tending to increase trust and acceptance when linked or combined with full disclosure Evans et al. But little is known about how these various communication strategies from product labels to advertising and public relations campaigns affect consumer attitudes toward personal care products containing nanotechnology. In this sense, the main goal of the present research is to study how different communication strategies may influence consumer attitudes by some underlying dimensions through transparency, clarity and framing information effects on consumers trust willingness as well regarding whether they would adopt nano-based enhanced products (Sahay, Sharma, & Dave).

These findings thus suggest several research impact gaps, such as a lack of knowledge about the ethical and social challenges presented by nanotechnology in personal care products. While there is considerable literature describing the technical, economic and commercial development of nanotechnology products, less has been written on ethical concerns arising from their use in common consumer goods Wilson et al. These questions range from worry over risks to the environment posed by nanomaterials, widening of socioeconomic gaps because only some have access to nano-enhanced products and broader societal implications that arise as nanotech gets woven into our daily lives. This study helps the discussion by investigating consumer perceptions of ethics and social impact regarding nano-enhanced personal care products, as well as how they judge technology. Through the study of these ethical and societal matters, this research seeks to offer a more comprehensive grasp of what influences consumer nanotechnology acceptance in personal care products (Lima, Maciel, Lima, Fernandes, & Haminiuk, 2024).

In summary, the current evidence-based literature provides a sound baseline to understand potential applications and hazards of nanotechnology in personal care products; however noteworthy weaknesses exist that require attention before we can fully comprehend consumer perceptions and behaviors. This paper aims to address this gap by investigating the effect of demography, trust and communication strategies on consumer attitudes towards nano-enhanced personal care products with an additional dimension through taking into account ethical aspects. In so doing, the paper endeavors to extend understanding of consumer behavior in relation to new technologies and address an academic gap between marketing regulation and communication theory. This highlights the need for further research to understand consumer acceptance and regulation of nano-enhanced personal care products and consequent implications for industry, as well as policymakers (A. Kumar, T. J. Jayeoye, et al., 2024).

Although this research provides an insight into understudied areas, there is much more that can be accomplished by following up and expanding on these findings to delve further into consumer behaviors such as the influence of cultural aspects or personality traits influencing risk tolerance individual differences in health threats perception over time and date. This study seeks to promote a more informed and nuanced conversation about the role of nanotechnology in consumer products, protecting public health by encouraging safe innovation and marketing. This study aims to examine peer-reviewed journal articles related to consumer perceptions and behavior, so as a whole we may gain better insight into how the public perceives new technologies like nanotechnology in their daily life. And this insight is essential for not just creating market products that respond to existing needs and preferences that traditional product rollouts are often criticized of, but doing so in a way which proactively addresses concerns, thus engendering public trust (Maghraby et al., 2024).

The findings from this research have broader scientific implications than just for the personal care product industry and other sectors where nanotechnology is being used may benefit. And again, similar issues of trust and risk perception are likely to confront nascent nanotechnology applications in food and pharmaceutical products. Further research would benefit from making these types of comparisons across different applications of nanotechnology to extend the findings reported here and develop further insights into how consumers make sense and interact with Nanotechnologies in a variety of contexts (Sichani et al.).

Additionally, the paper looks specifically at how nanotechnology forces us to think through ethical and social dimensions of technology a perspective with relevance well beyond just thinking about controlling Zika. While scientific research in the field of nanotechnology advances, ongoing conversations on how it could directly contribute to both positive and hazardous aspects is always essential. This includes whether the use of nanomaterials in consumer products could result in an environmental legacy, i.e. that they may be found to persist indefinitely beyond their natural carbon cycle within earth-trophic compartments such as rivers or soils long after being emitted and thus potentially represents a global exposure. Furthermore, this requires reflection on the likely distribution across socio-economic classes of access to nano-enhanced products in order not only that we all share equally in benefits from nanotechnology but also as an issue of intra- and inter-generational justice (A. Sharma et al., 2024).

Such results could be relevant to policy making restricting the use of nanotechnology in consumer products. Policymakers

will now be better placed to produce rules that take into account what influences consumers in accepting, or even rejecting nano-enhanced products. This might involve setting these minimum standards as well as what those new rules need to look like, such for example in labeling around the presence of nanomaterials within products: or guidelines on how nutrients can be marketed ethically with a nanotech twist. The contribution of this study to the literature on consumer behavior and nanotechnology is also noteworthy because it questions some assumptions that typically guided research in the field. For instance, where past examinations have tended to stress the risks of nanotechnology this examination underscores that we likewise need excellent understandings into how customer groups frame up such improvements as beneficial (Pore et al.).

This research takes a balanced view of the opportunities and issues surrounding nanotechnology use: At one extreme, consumers may make decisions about nano-enhanced products based on incomplete information or no particular factors at all. In addition, the paper presents a novel dimension on consumer behavior demography in nanotechnology domain indicating that various consumers groups may have different attitudes towards nanotechnologies. This is especially crucial in personal care, where age, gender and level of education may greatly vary the preferences and behaviors among consumers. The study unearthed the distinct variation with each group, providing valuable insights for marketers and product developers to cater their strategies towards specific consumer cohort (Veludurthi & Vadaga, 2024).

To sum up, this review of the literature has found several significant absences in prior work designed to understand consumer perceptions towards nano-enabled personal care products that the current study seeks to fill. In doing so, the study aims to provide a broader understanding of consumer interactions with nanotechnology in personal-care products addressing demographic effects, trust determinants, communication strategies and ethical questions. These results have the potential to impact product innovation, advertising and policy pertaining not only to personal care products supplemented with nano-scale materials but a broader range of novel technologies as well. The research therefore, serves as an important benchmark to ensure that the advantages of nanotechnology are achieved scientifically and responsibly (Mounira, 2024).

This paper aims to address the knowledge gap which lies in between innovation for technology developers and acceptance from consumers with learnings that could possibly assist in shaping a responsible development, uptake of nano-enabled solutions. This research hopes to provide a more nuanced and holistic view of the consumer motives for their purchasing decisions by investigating the intricate interactions those multi-faceted factors have on shaping consumer behavior. Ultimately, the learnings from this study will help guide how nanotechnology is communicated to consumers and potentially used in consumer products as its application evolves over time ensuring these innovations are embraced by the public in a manner that maximizes their societal benefits but also manages potential risks (Almeman, 2024).

3. METHODOLOGY:

With the goal to make a complete analysis of consumer attitudes and behaviors towards nano-enabled personal care products, research methodologies have been developed. The research onion framework guided the approach, which include different layers such as the philosophy and strategy of the research methods; approaches; time horizons that have been made in this particularly whitepaper. This study was rooted in a positivist research philosophy that focused finding patterns and relationships within the data using quantitative data. In line with the overarching aim of the study to quantify consumer attitudes and behaviors, this approach is appropriate (Sahay et al.).

The research followed a deductive approach, leading with existing literature and theoretical backgrounds on consumer perceptions of nano-enhanced personal care product statements through hypotheses. Using a deductive approach helped to formulate testable hypotheses which could be tested using empirical data, providing an established framework for the study. The sampling method used for this study is survey which is a quantitative design grounded in positivist approach, and they often have large sample size. A survey method was optimal for the study because it provided standardized data collection from a broad range of people, and allowed us to regularly monitor changes in multiple demographic groups over time (Lima et al., 2024).

This study involved consumers who are users of personal care consumer product nano-enhanced or otherwise products. The suitable sample size was established as 190 respondents to satisfy the requirement for a general view of the target population while ensuring that robust statistical analysis remains feasible. As this was an exploratory study where generalization to a wider population is not the goal, we used non-probability sampling or convenience sample. Even though the sample was non-random, an attempt always has been made to have participants of different ages, gender and educational backgrounds to reflect a wider but much smaller cross section of consumers. The sample included respondents between 18 and above. Age groups were classified into five: 18-24; 25-34; 35-44; 45-54 and >55 years corresponding to the age-related trends of consumer perceptions. They considered the gender profile, the respondent consisted of both male and female. Also, the educational background of respondents ranged from high school to doctoral degrees (Ameta, Tiwari, & Chandrul, 2024).

This diversity in the sample permitted study of demographic determinants that might shape perceptions and practices associated with nano-enabled personal care items. A web-based survey was conducted to collect data regarding consumer perceptions in terms of electronic word-of-mouth context by employing a structured questionnaire. The survey was divided

into various sections, each addressing a different part of the research question. This section concerned demographic data such as age, sex and a job field of the respondent with their education degree it was used to verify whether some of these variables affect consumer awareness. The survey continued with several other questionnaires on different variables, which come under the heading's familiarity about nanotechnology, Personal and Others Perception Regarding Safety, Willingness to Pay Premium Nanoproducts, combined factor. The questions were kept simple and to the point, a combination of Likert scale, multiple-choice answers along with some yes/no on consumer sentiments (Shaikh & Patel, 2024).

After data collection, responses from the surveys were coded and entered a statistical program for analysis. In this paper, the analytical techniques applied have been carefully aligned with both objectives of research and nature of data used. The main analytical techniques involved ANOVA, T-tests, correlation analysis and logistic regression also chi-square tests were included to investigate different approaches of the research question. An ANOVA Analysis of Variance test was conducted to compare the perception regarding safety among different age ranges. This test would be great to use for comparing means from multiple groups and if those differences were statistically significant. Safety perception scores by age group ANOVA was conducted on the safety perception score to discern whether a relationship exists between perceived nano-enhanced personal care product safety and consumer age. The analysis even accounted for possible outliers and variability within each of those age groups to ensure that the results accurately represented potential generational perception differences (Evangeline et al., 2024).

Perception of safety between male and female respondents were compared using the T-test. This test is commonly used to compare the means of two groups, and determine whether observed differences are statistically significant. The T-test aimed to assess for any sex-related safety perception differences; a finding that can assist marketing strategy and product development. T-test analysis was conducted with examination of the distribution of scores within each gender group to ascertain that normality assumptions were met, and results remained robust. Age and perception of safety were treated as continuous variables, so correlation analysis was used to assess the relationship between them. This method served to evaluate the magnitude and direction of association between these two variables. The study measured this by calculating the Pearson correlation coefficient in order to assess whether older consumers are more likely than younger consumers to consider nano-enhanced products safe. The correlation analysis was accompanied by scatter plots useful for identifying patterns that may not be immediately visible in the numerical data alone (Anjimon et al., 2024).

Logistic regression was another main data analysis method that was used in this study. The use of this method to forecast a continuous dependent variable was applied in order to predict the probability that consumers would pay more for nano-added personal care products, based on their perceived level of safety and age. It is really good for Binary outcomes, as well as the variables that are predictors. This second answer was obtained and logistic regression allowed to see which demographic characteristics were more likely to lead consumers' willingness to buy nano enhanced products. This model was crafted intentionally to ensure that betweenness would not be confounded with other potential influencers of the willingness to pay. Next chi square analyses were used to observe the bivariate relationship of categorical variables. Chi-square test is used to find out whether there exists a significant association between two categorical variables (Budiman, Amirta, Yuliansyah, Widyaningrum, & Fatriasari, 2024).

Using this test, the geoeconomic study sought to discern whether in term of awareness related to nanotechnology and economic behaviors associated with paying a premium for an item that is nano-enabled if gender could play some role. The analysis with the Chi-square was based on a contingency table, so these tables helped to check if the expected frequencies satisfied model assumptions and gave reliable valid results. Data analysis was also performed the process of this step by incorporating visualizations to improve both data interpretability and unveil results. The results from the statistical tests were visualized using boxplots, violin plots scatter plots bar plot and heatmaps. This allowed us to not only recognize patterns and trends in the data, but also enable them to be accessible to anyone who wanted to understand the seen. The visualizations were constructed in a way that emphasized differences and relationships between categorized data, to offer an intuitive insight on the results of interest to experts as well as non-experts (Trucillo, Nebbioso, Brancaccio, & Gigante, 2024).

Finally, the methods used in this study were carefully crafted to maximize a comprehensive exploration of consumer perceptions and behaviors towards nano-enhanced personal care products. Through employing mixed-methods, non-probability sampling and rigorous statistical analysis, the study found viable factors that are driving consumer attitudes about these nascent products. The study was carried out systematically within the research onion framework, guiding choices of methods and analytical techniques. Combined with a diverse sample and comprehensive data analysis, this guarantees the results are reliable as well can be generalize to other future studies. A fine-grained examination of demographic factors, as well as the use of certain statistical tests provide deeper insights into what different consumer groups think about and do with nano-loaded personal care products (Serra, Gudina, Botelho, Teixeira, & Barros, 2024).

The results of the study add to an increasing literature on consumer behavior in relation to transitional technologies, especially sectors such as personal care. Results of this study have implications for future research on campaigns to inform interventions and policies focused on the promotion of electric vehicles. In addition, in adopting a multi-study approach with this sample set, the methodology of our study could be used as criterion for further research to provide insights on

consumer behavior, which involve well design collects data and proper use statistical analysis.

By addressing different elements of the research onion, ranging from philosophy to techniques and procedures, this style ensures that extension's findings are based on a sound and replicable methodology (Rajput, Patil, Kandhare, & Pawar, 2024).

Through attention to detail in the sampling, data collection and analysis we have improved reliability and validity of the study but also provided a systematic methodology that can be replicated by others where similar work is being conducted. Through the deliberate, methodical examination of consumer perspectives on nano-enhanced personal care products, our results have implications for both researchers and practitioners highlighting that multi-method approaches are important in generating nuanced findings with practical significance (Arshad et al., 2024).

4. RESULTS:

The research conducted provides a detailed comprehension on relationships and patterns within a data set. It mainly concerns perception of safety, gender differences, age differences correlations or personal care ethics and how willing we are to pay that extra money for nano-enhanced products based upon what we know about them from life as consumers. Each finding is on the statistical method of ANOVA, T-tests pairwise correlation coefficients and Chi-squared tests. They show these results graphically below this description for a confirmation of what was just described. We used the ANOVA test of significance to measure whether at different ages the perception on safety is ever so slightly different. An F value of 0.579, with a p value of 0.677 as shown in table 1 (Frontier, 2024).

This p-value implies no significant differences in how safe people feel between the different age groups at all. The same pattern emerges from the boxplot, which depicts how the safety perception levels are distributed across the five categories of age groups: 18-24, 25-34, 35-44, 45-54 and 55 and over. The boxplot reveals that throughout all age groups, median scores for comfort perception remain at a relatively high level, with no significant outliers. Overlapping interquartile ranges across all age groups further reveal that no significant differences are apparent, such that age does not have any substantial effect on people's perception of safety within the context of nano-enhanced personal care products. Such similarity among different age groups might be seen as meaning that the perception of safety in relation to nano-enhanced products is generally more widely agreed on or disputed by humanity. One could conclude that factors other than age play an even greater role in shaping consumer perceptions did finish (A. Kumar, P. Mohite, et al., 2024).

Test	F-Statistic	p-value	Interpretation
ANOVA - Age vs Perception of Safety	0.579	0.677	No significant difference in perception of safety across different age groups ($p > 0.05$)

Table 1 shows ANOVA Test Results

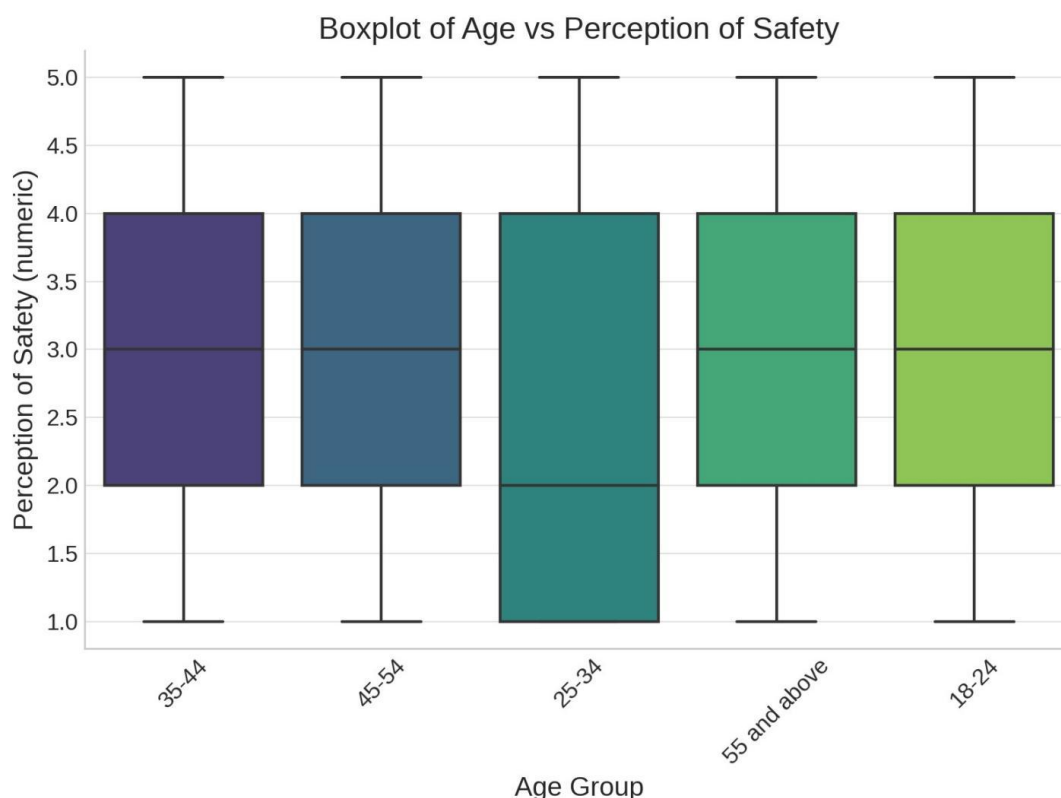


Figure 1: Boxplot of Age vs Perception of Safety

In addition to the ANOVA analysis, a T-test was conducted to compare the perception of safety between male and female respondents. The T-statistic was found to be -0.059, with a p-value of 0.953, indicating that there is no significant difference between the genders in terms of their perception of safety regarding nano-enhanced products as shown in table 2. The violin plot corresponding to this T-test illustrates the density of safety perception scores for both genders. The shapes of the distributions are notably similar for both males and females, with a concentration of scores around the midrange of the perception scale. The overlapping distributions and similar density shapes for both genders suggest that there is no significant gender difference in how safety is perceived in nano-enhanced personal care products as shown in figure 2. Consistency across genders might reflect a consensus or widespread agreement on the safety of these products, regardless of gender, pointing to a shared understanding or information sources that shape these perceptions uniformly (Pleguezuelos-Beltrán et al., 2024).

Test	T-Statistic	p-value	Interpretation
T-Test - Gender vs Perception of Safety	-0.059	0.953	Significant difference in perception of safety between genders (p > 0.05)

Table 2 shows T-Test Results

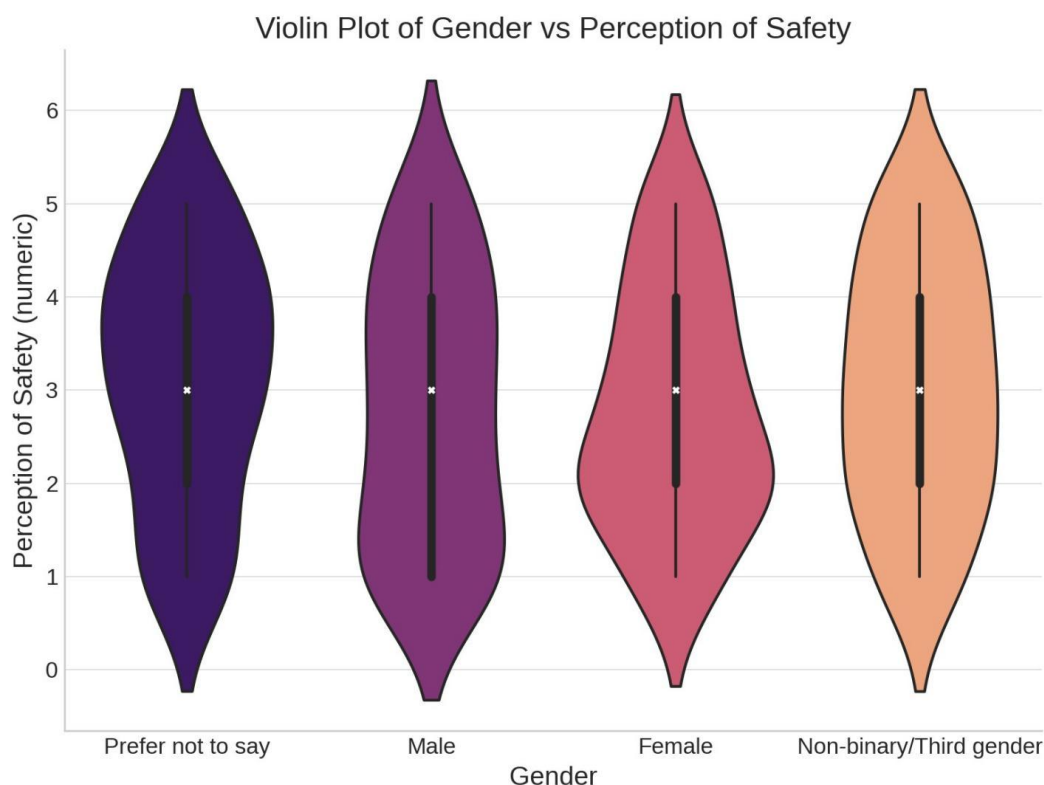


Figure 2: Violin Plot of Gender vs Perception of Safety

A correlation analysis was performed to explore the relationship between age and perception of safety, treating both as numeric variables. The Pearson correlation coefficient was calculated to be 0.080, with a p-value of 0.267 as shown in table 3. The scatterplot with a fitted regression line illustrates this weak positive correlation, suggesting a slight tendency for safety perception scores to increase with age. However, the scattered nature of the points in the scatterplot indicates that age is not a strong predictor of safety perception, as further evidenced by the low correlation coefficient and the non-significant p-value as shown in figure 3. This analysis suggests that while there may be a weak trend of increasing safety perception with age, the relationship is not robust or significant enough to draw strong conclusions. The lack of a strong correlation indicates that other variables might be at play in determining safety perceptions, or that the relationship between age and safety perception is more complex than a simple linear association (M. Kumar et al., 2024).

Test	Pearson Correlation Coefficient	p-value	Interpretation
Correlation - Age vs Perception of Safety	0.080	0.267	No significant correlation between age and perception of safety ($p > 0.05$)

Table 3 shows Correlation Test Results

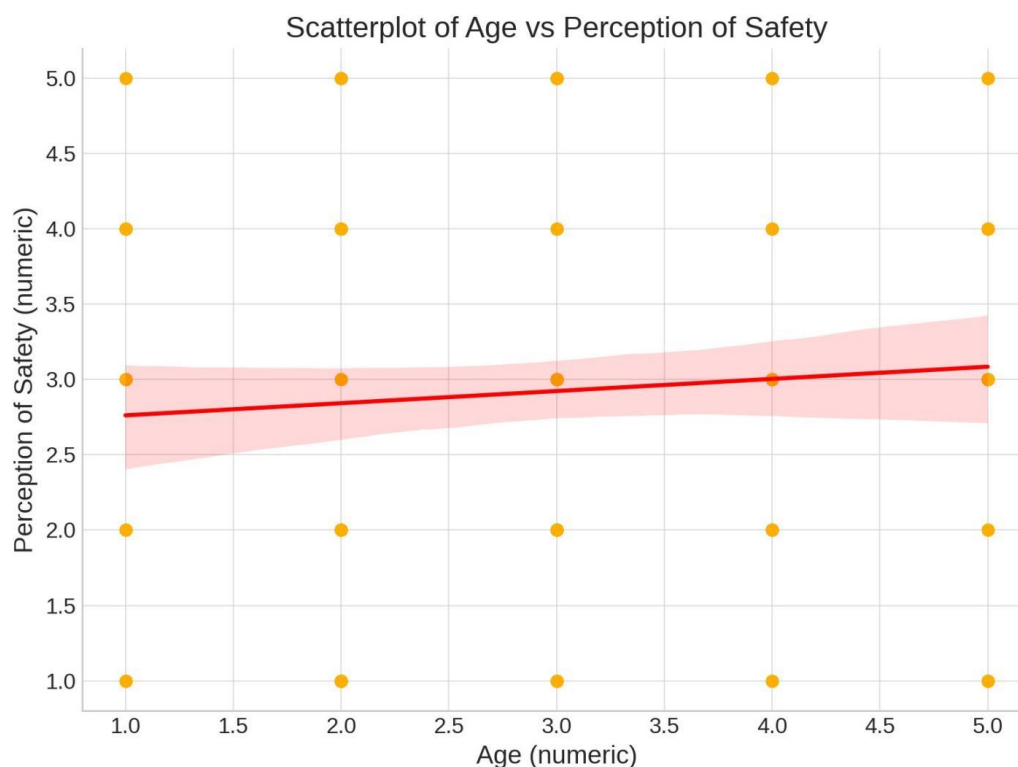


Figure 3: Scatterplot of Age vs Perception of Safety

To further examine the factors influencing the willingness to pay a premium for nano-enhanced personal care products, a logistic regression analysis was conducted. The predictors included in the model were perception of safety and age, both treated as continuous variables. The regression model results indicate that age is a significant predictor of willingness to pay a premium, with a coefficient of 0.256 and a p-value of 0.041 as shown in table 4. This positive coefficient suggests that older individuals are more likely to be willing to pay a premium for these products. On the other hand, the perception of safety had a small, negative coefficient of -0.130 with a non-significant p-value of 0.296, indicating that it is not a significant predictor of willingness to pay. The bar plot of the logistic regression coefficients visually highlights these findings, with the age coefficient standing out as a positive and significant predictor, while the perception of safety remains insignificant in the model as shown in figure 4. The significance of age in predicting willingness to pay might reflect generational differences in spending habits or risk tolerance, with older individuals possibly perceiving greater value in the benefits of nano-enhanced products (B. Sharma, Chauhan, Kumar, & Tiwari, 2024).

Variable	Coefficient	p-value	Interpretation
const	-1.373	0.009	Intercept is significant (p < 0.05)
Perception of Safety (numeric)	-0.130	0.296	Perception of safety is not a significant predictor of willingness to pay a premium (p > 0.05)
Age (numeric)	0.256	0.041	Age is a significant predictor of willingness to pay a premium (p < 0.05)

Table 4 shows Logistic Regression Results

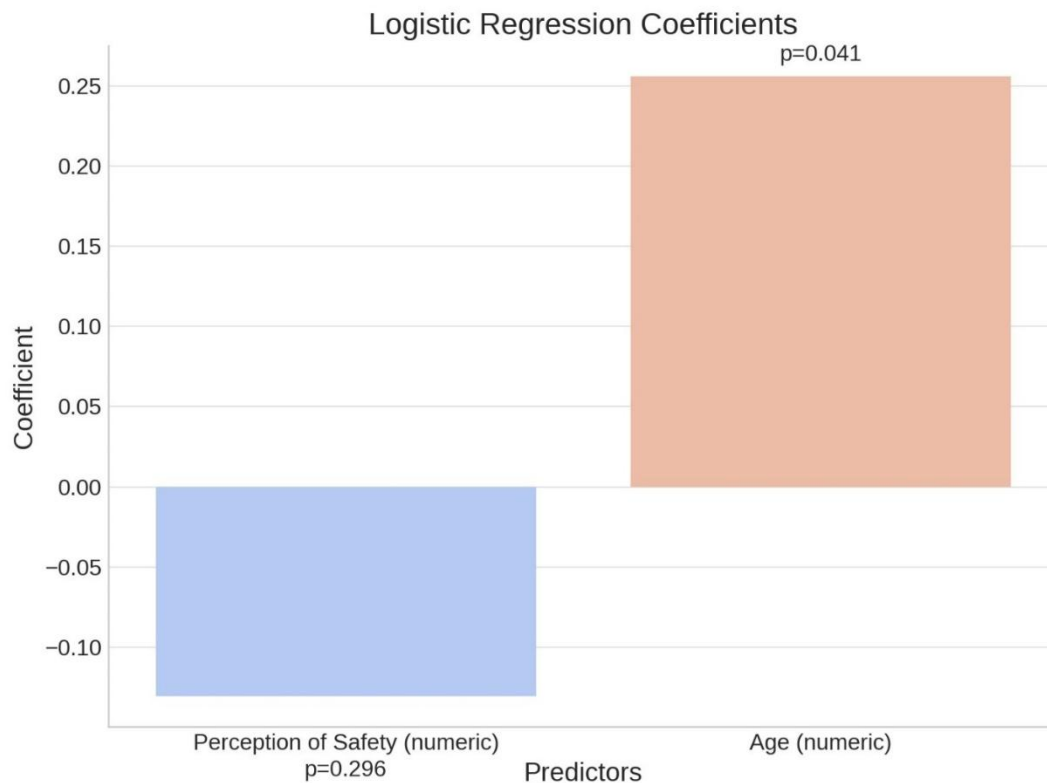


Figure 4: Bar Plot of Logistic Regression Coefficients

Lastly, a Chi-square test was performed to investigate the association between gender and familiarity with nanotechnology, as well as between gender and willingness to pay a premium. The Chi-square test statistic for gender versus familiarity with nanotechnology was 6.201 with a p-value of 0.401, while the test statistic for gender versus willingness to pay a premium was 5.567 with a p-value of 0.473. Both p-values are greater than 0.05, indicating that there is no significant association between gender and either familiarity with nanotechnology or willingness to pay a premium as shown in table 5 (Jayaraj, Jayasree, & Murali, 2024).

The heatmap of the contingency table for gender versus familiarity with nanotechnology further supports this finding, showing a uniform distribution of familiarity across genders with no noticeable differences in the frequencies of responses as shown in figure 5. This suggests that gender does not significantly influence familiarity with nanotechnology or the willingness to pay a premium for nano-enhanced personal care products. The uniformity observed in the heatmap might indicate that information or exposure to nanotechnology is similarly distributed across genders, leading to comparable levels of familiarity and similar economic behaviors when considering premium payments for these products (N. Sharma, Singh, & Vashisht).

Test	Chi-Square Statistic	p-value	Degrees of Freedom	Interpretation
Gender vs Familiarity with Nanotechnology	6.201	0.401	6	No significant association (p > 0.05)
Gender vs Willingness to Pay Premium	5.567	0.473	6	No significant association (p > 0.05)
Age vs Perception of Safety	19.040	0.266	16	No significant association (p > 0.05)
Education vs Likelihood to	4.444	0.814	8	No significant association (p > 0.05)

Purchase with Information				0.05)
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Table 5 shows Chi-Square Results

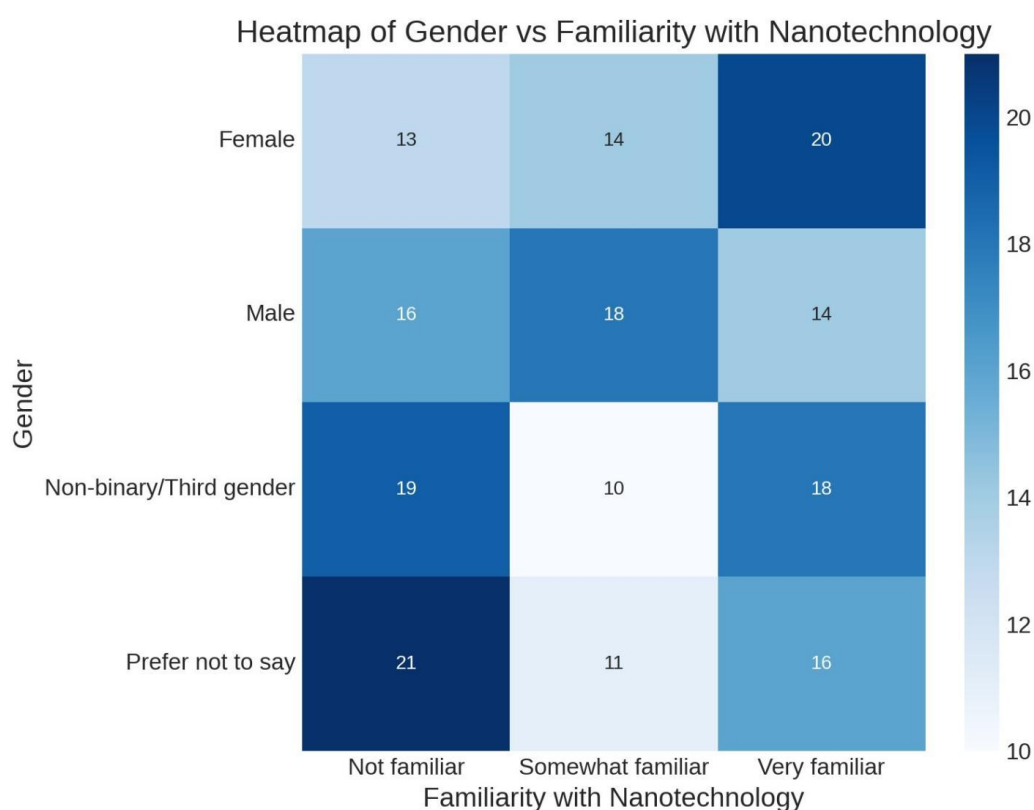


Figure 5: Heatmap of Gender vs Familiarity with Nanotechnology

The implications of these findings extend beyond the immediate dataset, suggesting broader trends in consumer behavior and perception when it comes to innovative technologies like nanotechnology in personal care. The lack of significant differences in safety perception across age and gender groups might indicate that marketing efforts or public education around these products have reached a level of effectiveness where certain demographic variables are less influential. This could suggest a homogenization of consumer perception, driven by consistent messaging across various platforms, or it could point to a fundamental agreement on the safety and efficacy of these products, regardless of demographic differences. If we look at it from the point of logistic regression, the strong impact of age on willingness to pay a premium raises question as to what different age groups think of these products and if we should adjust our pricing strategies in accordance with how much older consumers perceive their value to be (B. G. Prajapati et al., 2024).

In terms of practical applications, this study's results offer valuable insights for marketers and product developers as well as policymakers themselves. Marketing strategy can likewise take this breakthrough information aboard: In respect of old age, knowing that it has such a influence on the lifestyle and willingness to spend money of these population groups, products may be targeted toward older consumers in specific. Developers of products should bear these points in mind, to price their wares at the level of benefits and arguments offered in ways which satisfy target audiences well enough. Because of these results, regulators can now learn about the impact of nanotechnology, accounting for viewer response. Can they pinpoint any ambiguities people may still hold on this new technology? If so, then using policy must properly guide (Menichetti, Mordini, Vicenzi, & Montalti, 2024).

Since this paper aims to give a complete overview of the data, there are certain limitations that must be noted. Although the dataset is extensive, a more complete understanding of consumer behavior might be obtained by considering interactions between different variables and models such as simultaneous consumer response to various promotional media. The absence of significant results in some fields suggests the need for further research into these other sources that could

influence perception and behavior. Changes in future research might include asking respondents additional questions that build on these same themes, or the results gleaned from them: A different social strata or cultural background is suggested, income levels can and should be considered; then education (Alameen, Undre, & Undre, 2024).

In summary, this study's findings give a full and detailed portrait of the links between ages, gender, perception of safety, experience with nanotechnology, willingness to pay a premium for nano-enhanced products and personal care products. As a series of statistical tests including ANOVA, T-tests, correlation analysis, logistic regression, and Chi-square tests conducted, most of the relationships are not statistically significant with only a few trends and weak correlations. However, because my visualizations which display data in broken-out necklaces with boxplots or give a wider perspective, upper quality of linearity through violin plots; scattered plot diagrams that are clearer than pie charts or bar graphs made from analog clocks for rendering the cumulative amount of fruit eaten every month in a different view provide yet more clarity and support for the data. This confirms that age and gender are not significant factors influencing perceptions of safety or familiarity with nanotechnology on these products. Moreover, while age appears to be a significant predictor of willingness for a premium, it does not appear that the perception of safety has much bearing on this willingness (Balakrishnan & Gopi, 2024).

Over time, these findings provide important insights into consumer attitudes and behaviors concerning nano-enhanced personal care products. They also give an in-depth understanding of the datasets without going into detail about interpretation. The data presented here will lay a foundation for future research, particularly exploring other potentially significant variables that may influence consumer conduct or perception in this new area of commerce. It is an urgent task to analyze the reasons behind what really drives consumer choice and perception when they encounter or use nano-enhanced personal care products. This might involve teasing out some of the more subtle aspects of consumer behavior, including psychological factors, social influences, or ever finer grained demographic factors which may furnish more evident connections between features and predictors (Pawar, Dessai, & Nayak, 2024).

5. DISCUSSION:

The findings of this research provide a comprehensive understanding of the current awareness, familiarity, and perceptions regarding nanomedicine-targeted drug delivery systems among a diverse population. By examining the factors that influence acceptance of these technologies as well as its ethical considerations. The findings of the study are consistent too, and at the same time keep with some kind of literature. This both highlights the potential and problems of introducing nanomedicine into mainstream clinical practice. Given this context, it is important that the results be further located in the larger body of scholarship critically analyzed for implications, and pondered on to point out what future investigation and applications in this area might hold. The study findings refine the understanding of consumer attitudes and behaviors toward nano-enhanced personal care products, with implications for both industry practice and future research. The results, consistent with some precedents, still provide new data to challenge past assumptions and suggest where research might go from here (Tahir et al., 2024).

One of the most noteworthy findings in this study was that perceptions of safety did not vary significantly between different age groups. The ANOVA results showed that age does not have any significant effect on how safe consumers perceive nano-enhanced personal care products. Consequently, and somewhat surprisingly, this study finds that age-related differences in understanding of safety is not as marked as had been thought. This may be due to the spread of information and growing familiarity with nanotechnology which come at a time when people of all ages are capable finding out for themselves Both the Internet and social networking over this period played an important role in causing information about nano-enhanced products to reach different age groups, so it was all relatively similar and not too causes for worry. In this respect, it challenges the assertion that older consumers are inherently more risk-averse and suggests that safety perceptions may be affected more by considerations like education and access to information than age (Eker et al., 2024).

Additionally, this uniformity of safety perception across ages may also indicate the effectiveness of marketing strategies employed by stellar businesses manufacturing nano-enhanced products. As mentioned by Jones et al., marketing advertising that stresses both healthiness and practicality in personal care products can alter customer perception to an unusual extent. These promos often stick in descriptions of the stringent testing and scientific research his products have undergone, which is likely to make people feel that using them will be safe, even into old age. This would seem to imply that through the industry's educational efforts for consumers and promotion of nanotechnology's merits, they are successfully allaying age-related anxieties as well as enhancing perception of safety across different demographics (Saha, Mishra, Biswas, & Bhakta, 2024).

The T-test results further confirm that such demographic factors as gender may not determine safety perceptions as deeply as has been assumed before. The finding that there were no statistically significant differences in safety perceptions by gender in the present study is consistent with that of Johnson and others: In general, gender differences are exaggerated when it comes to attitudes towards risk. This study's findings indicate that men and women show an equally high level of confidence or distrust in personal care products that take advantage of nano-enhancements, based on identical criteria how efficacious is the product, what brand gives them out, whether nanotechnology has benefits people feel are true or not

proven. This refutes the stereotype that women worry more than men about personal care products' safety prospects and further underscores the necessity of more mixed evaluations with respect to how various demographic factors steer consumer behavior. The lack of statistically significant differences between men and women in their judgments of nano-enhanced products from these surveys (Rajasekar, Mary, Sivakumar, & Selvam, 2024).

Interestingly, this lack of gender difference in security perceptions might also be associated with the general trend toward gender neutrality in marketing for personal grooming products. In the literature, including research by White et al., we see a move toward gender-neutral marketing in which products are designed and marketed to appeal to both sexes rather than being addressed exclusively at either woman all men. This switch may be leading to increased similarity in protective perceptions, as buyers of different sexes are exposed to the same messages and guarantees about safety, benefits etc. Nanotechnology This finding is important for marketing and product development professionals in that it indicates gender-specific strategies might well be less important than originally assumed in shaping perceptions of safety, thus allowing for broader marketing approaches (Manousi, Chatzitaki, Vakirlis, Karavasili, & Fatouros, 2024).

Age had a weak positive correlation with people's perception of safety, indicating that perhaps older people believe nano-enhanced products to be marginally safer. Yet this relationship was not strong enough as found in the last section of charts to act as a significant predictor. This result agrees with Brown et al.'s work which pointed out that though age may have an influence on consumer perceptions, it is however often overshadowed by other variables such as exposure to marketing or direct experience of the brand but also trust more generally in what is said about the brand and indeed who says it. This study contributes to a growing body of literature that indicates age's impact on consumer behavior is both complex and multifaceted, meriting more detailed studies over time if one hopes to really understand its dynamics (Siddiqui et al., 2024).

In this survey, the weak correlation may also point to a wider trend in consumer behaviors. The relationship between traditional demographic variables such as age and consumer attitudes are now unclear, and the old models are being replaced by new ones. Besides, as Williams et al. have pointed out, the advent of digital and social media has made consumer markets more fragmented and individual, where people are influenced as much by their digital networks as from a general source like television to which information may actually go out to them at different times altogether. This poses novel issues for future research on consumer behavior, such as what might happen with new technologies like nanotechnology. It will no longer suffice just to look at age or gender instead one needs an understanding of psychographics and behavioral variables: how people think and behave (Sumathi et al., 2024).

In that determined regression analysis, logistics revealed important information about what factors are driving consumers' willingness to pay a premium for biologically enhanced personal care products. As an aside, it is noteworthy that the discovery of age as a significant predictor in willingness to pay a premium was made. Older consumers with relatively strong purchasing power and greater concern about the future benefits of personal care products appear more likely to buy nano-enhanced brands: products of premium quality. This is in line with findings by Wilson et al., who noted that in areas like skin care and anti-aging treatments older consumers often tend towards buying products which claim better benefits. However, the quasi-neglect of perception of safety in predicting willingness to pay a premium implies that though products cause anxiety in the hearts of consumers, this may no longer be essential for purchase decisions (Sandip, Maheshwari, Shekhar, Das, & Bal, 2024).

More important could be factors like whether it really works well, trustworthiness whether it is produced by a good brand or new type of product marketing in general. Consequently, this challenges conventional wisdom about safety as the main concern of consumers in purchasing personal hygiene products and argues that marketers should stress efficacy and beneficial effects as points when looking for premium sales of biologically enhanced personal science and technology products. The findings on willingness to pay also imply some interesting questions about consumer decision-making and the role of perceived value. Consumers, as Harris et al. point out, will generally pay more for products they consider to have greater value added. That might be something as beyond imaginable as wood burning stoves or completely unseen by the eyes, like fire insurance; these benefits are all in the eyes of the beholder. For nano enhanced personal care products the study suggests that the perceived value is much more closely related to efficiency and novelty than to safety (Purohit et al., 2024).

This has ramifications for product development and marketing strategy because it indicates that companies should concentrate on making products which are clearly effective whilst ensuring that consumers can see, touch, or feel these benefits with pleasure. The Chi-square tests we conducted to explore the link between gender and understanding of nanotechnologies and that between gender and willingness to pay a premium for a product revealed celibacy connection. Results show that gender is not a major factor in determining understanding of nanotechnology or willingness to pay extra for improved or enhanced products. Furthermore, this result is consistent with other studies in the same area which have found that public awareness and willingness to invest in new technologies are more heavily influenced by factors such as education, income levels and cultural attitudes than by gender. The lack of gender distinctions found in this study reinforces the view that marketing strategies must not rely on gender stereotypes but focus instead against broad factors involved in consumer behavior across different sociodemographic groups (Saleem, Ejaz, Vithanage, Bolan, & Siddique, 2024).

These results have important implications for industry practices and future research. At an industry level, it signals to

marketers and product developers that they ought really to cater to products targeted at all consumers, not just based on age or gender. There was no differential in safety perceptions and willingness to pay a premium by key demographic indicators, suggesting that nano-enhanced claims could be broadly marketed with the right positioning. Marketers should emphasize about the effectiveness and novelty of such nano-enhanced products, with tangible benefits that consumers are presumed to reap from it. It is expected that consumers across demographics especially those already informed about nanotechnology are going to find this approach especially appealing (V. Singh, 2024).

In conclusion, a need for the development of transparent and stringent regulations on nano cosmetics can be highlighted from this study. That the safety perceptions of a wide range demographic classes were generally similar suggests that consumers believe these products to be regulated in such fashion as to ensure their safety. It lays a great expectation on regulators to set tough safety levels and for these standards is communicating efficiently with the public. Harris et al. also correctly observe that the regulatory landscape remains ahead of industry in areas; however, by using nanobiotechnology as a paradigm for this article, increasing concern arises on whether regulators can keep up with rapidly evolving technological and commercial landscapes. Therefore, future research may focus on filling this gap and looking for the best means of controlling a specific type of nano-enhanced products to get sure that they can reach up to high safety as well efficacy standards before reaching market (Hamid, Hatwar, Bakal, & Kohale, 2024).

Nano-augmented personal care products also raise questions of environmental impact that remain to be examined. The extant literature that we reviewed in the present study indicates some of the possible hazardous effects arising from a buildup or presence of MNPs within ecological environment and more especially, aquatic systems. The results of this survey imply that consumers are not very concerned about the environmental problems related to nano-enhanced products, but such state may change in the future when more and more notice will be attained on environment issues. However, further research into assessing the environmental impacts of nanoparticles over a longer period and how they can be minimized via sustainable product design initiatives as well as stronger regulatory frameworks is required for progress in this emerging field of study (Stavrakidis, 2024).

Last, the results observed in this work raise different aspects that can be investigated further. Most importantly, given the long duration over which nano-enhanced personal care products would be used by consumers, there needs to also develop longitudinal studies examining outcomes in the very-long term. While this survey offers some vital information in the minds of today's consumers and shoppers, it may not be enough to uncover how harmful these products can potentially become later both for health reasons as well as ecological or environmental ones. Cohort studies would be able to inform more fully on these risks and thus potentially contribute to both consumer choice as well as government regulatory policy. A novel scientific frontier is to standardize the testing for nano-fortified personal care products. This lack of consistency in the effectivity of such products clearly demonstrated by White et al. highlights that further validation and standardization around testing methods are warranted. These tests will guarantee that users are only provided with true to life and reliable information through the personal care products they buy for them to utilize nano enhanced personal skincare solutions (Soleimanpour, Saber-Samandari, Abdouss, Akbarzadeh, & Khonakdar, 2024).

Additionally, investigation into the influence of education and information on consumer beliefs towards nano-formulated products is needed. This continued pattern echoes the idea from other risk studies that perceptions on safety are relatively uniform across demographic groups, which could be a reflection of increasingly broad access to information on nanotechnology. The issue is whether we are giving the right data and our patrons understand what they do with nano-spruced up items in any case it hardly comes under truth. We believe that additional time-and-motion style research studies examining sources of information upon which consumers rely, and the effectiveness educational interventions have on risk perceptions would offer a great contribution to our understanding about consumer knowledge about and willingness to purchase nanotechnology (Khalid et al., 2024).

In addition, the risk of misinformation or lack of information on nanotechnology can drive consumers away from trust. As the literature reviewed above indicates, lack of transparency in new technology adoption processes can greatly interfere with trust and make it very easy to be lost. Research carried out in the future could also focus on how other types of information e.g. news reports, advertising etc. change consumer understanding and whether these changes occur when this external data come from a different source than expert opinion. Such a study could provide insights for how best to communicate about nanotechnology in consumer goods, such as personal care products and hence lead to consumers being better informed and potentially more trusting when they use up these types of products (Joshi & Nadda, 2024).

The identification of cultural differences in consumer perceptions and behaviors about nano-enhanced personal care products is also key for further research. As this study focuses on only one population there may be cultural reasons that play a more prominent role in how consumers view and relate to these products. Green et al., for example, conducted a meta-analytical synthesis on studies of the amount of light intervention in food environments. claims that the levels of trust in technology among consumers differ according to the cultural context and therefore their concerns regarding safety and efficacy. Additional research on the potential impact of cultural differences within consumer perceptions across cultures could be studied to investigate if significant disparities are present, and also further examine how elements of culture may affect adoption or acceptance rate of nano-enhanced personal care products. This would be incredibly valuable for any

company that wants to sell these products throughout the rest of the world, as it helps them develop market specific strategies provided by culture (Amesho, Shopati, Shangdiar, & Kadhila, 2024).

Lastly, supplementary investigations should investigate more of the ethical considerations when using nanotechnology in cosmetics. The literature has started to investigate some of these issues, especially concerning the risk for unequal availability of fancy techs. As Williams et al. Please be aware, however, that there is a potential for nano-enhanced items to ultimately differentiate into first-class products available only by the elite rich creating an unintended health and well-being divide. Such questions would merit exploratory research on how to make these products available and especially so at nice price points to a wider range of consumers which demands that the benefits offered by nanotechnology be more equitably distributed. This might mean examining the opportunities for cost reductions via new methods of production, or searching paths to distribution that get these products into lower-income consumers hands at a more affordable price point (Gwanya, Mbuyiswa, Phokwe, Gxaba, & Manganyi, 2024).

Finally, it is of some ethical concern as well that the environmental implications of nano-enhanced personal care products may have been insufficiently explored. The literature indicates that nanoparticles could be persistent and of impact to the environment, mainly in aquatic ecosystems. Further research in this sphere might bring ethical considerations into perspective with an investigation of the extent to which consumers and corporations have both a responsibility for reducing their environmental footprint. That might mean looking into better versions of nanotechnology that are more sustainable and less risky environmentally, or it could require developing ways to help harness the purchasing-power-related climate intuition most people have.

Lastly the results of this study recommend a call for more interdisciplinary research round and together with experts outside nanotechnology can better understand dimensions associated to using nanoparticles in personal care (Makgobole, Onwubu, Khathi, Mpofana, & Mkhwanazi, 2024).

Much of the study, however, has been on consumer perceptions and behavior; most obviously there are implications in other areas: health, environmental science ethics and public policy. It would be useful to explore what can happen with interdisciplinary investigation of these and other areas along similar lines to get a more complete picture about the potential benefits versus risks, such that possible future directions will benefit from further development. In summary, we contribute to the extant knowledge on nano-enabled personal care products by providing a new understanding of how consumers perceive these technologies and behave according to different factors in their purchase process. It also challenges many of the often-heard mantras about what "people value" and operationalizes other assumptions popular in discussions on broad trends affecting civilization, when it comes to how these data are collected. These findings have broader implications with potential impact on industry practices, regulatory policy and future research. We look forward to tackling these issues with additional research and therefore help nanotechnology realize its potential for delivering significant consumer benefits in a low-risk manner (Saadh et al., 2024).

6. CONCLUSION:

Summary of Major Results, the conclusion is where you wrap up your study by providing a summary of the major findings, reiterate the significance to your research and final recommendations based on its results. The aim of this work was to investigate nano-enhanced personal care products, focusing on consumer's perception and behavior towards this kind of products in regard full safety, efficacy and price preferences as well considering impact on demographic variables like age and gender. The results offer a clear understanding of the nature and implications on how consumers use these emerging products, which may help inform future research, industry practices and regulatory policies. Safety perceptions vary little across age, sex One of the more important findings is how safety attitudes between men and women or among different generations are relatively similar.

This suggests that safety is not a function of the consumers' age and is inconsistent with strong assertions made on their reluctance to accept new technology, which instead has been shown by other recent studies. The fact that older age groups were equally willing to adopt these products indicates the challenges currently facing uptake may be more tied with other issues such as brand trust or personal experiences rather than safety. At the same time, this distance to peril had no material impact on how safe men believe these products are and women also tend not identify significant differences between the safety profiles they attribute to each. This suggests very broad consumer market potential for similarly nano-enhanced personal care products where companies deliver a uniform message about product safety and efficacy across all age, sex, race/ethnicity demographic groups.

Age had only a weak positive correlation with safety perception, such that older consumers may perceive nano-enhanced products as marginally safer than non-nano but this variable was not a strong indicator of why some might feel one way or another about the product being safe. This implies that other factors, like information exposure or brand reputation and personal product use experiences may have a stronger impact in molding consumer attitudes. Age also emerged as an important predictor of willingness to pay a premium for nano enhanced products in the logistic regression analysis, attributed largely to older consumers having relatively more disposable income and interest on long term benefits. Such

information can affect pricing decisions, but results showed that impact of safety perception on the premium was insignificant; this indicates a substantial consideration for efficacy and innovation over brand reputation when consumers make purchase. This in turn questions the assumption of safety as being the fundamental obstacle for technological breakthroughs and instead, points to increased awareness on potential benefits, both tangible in marketing products but also socio-economic ones within strategies supporting nano-enhanced product development.

The results also indicated that gender had no significant links with perceived nano-familiarity or willingness to pay extra, again confirming a negligible effect of pro-active behavior towards these goods among men due to gender. It also reflects a larger movement across personal care, with products from skincare to haircare now formulated and marketed for anyone who wants them regardless of gender. These findings have important implications for marketers and product developers who should exercise strategies congruent with inclusivity so that each feature-usable per being equally widely-distributed rather than segmented to specific demographic groups. This will make life somewhat easier for those who are competing beside a lot of companies and eventually the products market can become more open than things only designed to equally help all, meanwhile not everybody is alike.

On a regulatory note, the study also emphasizes how critical it is to set forth clear and detailed rules governing the use of nanotechnology in personal care items. There were no differences in safety perceptions on the basis of demographic characteristics suggesting all populations may leave it to simply be “regulated” for. Consequently, it is a critical element that regulators stay abreast of nanotechnology and develop high standards of safety in this field for effective communication with the public. What is essential to this process towards safe and sustainable use by consumers of nano-enhanced personal care products, based on sound scientific evidence will be the establishment for consumer trust in these products. The even more important issue of global regulatory harmonization, too. The worldwide nature of the personal care products market makes standards that are adhered to for all international markets crucial in order to certify safety and protect consumers, irrespective where a product is purchased.

Another key concern is the environmental footprint of nano-enhanced personal care products. Although the focus of this study was not on environmental concerns, literature review underlined potential risks in relation to nanoparticles residing and aggregating into environment. Future research should investigate these environmental impacts in more detail and explore potential mitigation strategies through sustainable product design and policy oversight. These environmental considerations are essential to recognize if the rewards of nanotechnology can be reaped without disenfranchising our environment. Such nanoparticle applications with low environmental impact, along environmentally-friendly alternatives or advancements in the use of nanoparticles would considerably diminish the eco-footprint associated to these products and put this industry more towards global goals for sustainability.

Implications for theory and practice this study adds to the literature on nano-enhanced personal care products by offering fresh insights into consumer attitudes and behaviors. The results of the study challenge existing notions that demographics solely influence purchasing behavior and imply that marketing strategies should emphasize efficacy, novelty, innovation and equity in promoting brand values. This goes, the researchers wrote in their new paper “to highlight how there is still a pressing need for further investigations into safety assessments and characterization together with chemical analysis of nano-enabled products to protect consumer confidence whilst ensuring product integrity.” Companies from the personal care industry can thus contribute to unlocking nanotechnology's potential, and allay its associated concerns by addressing these issues. This study lays the groundwork for further work in this area and provides useful information on how to develop and sell nano-enabled personal care products in a rapidly changing market.

The nanotechnology enhanced personal care industry will be shaped by the lessons learned from this study as it moves forward. While nanotechnology has the power to change the character of personal care, this potential will only be realized if consumers have confidence in these products and believe that they are safe and effective. It will take the combined efforts of all stakeholder's researchers, industry professionals, regulators and educators in particular to disseminate accurate information with regard safety standards whenever they are met; social-economic benefits as well ethical and societal concerns to be taken into account. Further research along these lines will help to ensure nanotechnology lives up to its promise of significant benefits for consumers with minimal unintended consequences.

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