



Comparative Analysis of Knowledge and Self-Medication Patterns of Astaxanthin Between Generation Z and Millennials at K-24 A Pharmacy, Bandung City

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Abstract. Astaxanthin is an antioxidant supplement that is increasingly used for self-medication, particularly among Generation Z and Millennials. This study aimed to compare the level of knowledge and the self-medication patterns related to astaxanthin use between Generation Z and Millennials at K-24 A Pharmacy, Bandung City, in March 2026. This study employed a quantitative comparative design. Data were collected through structured questionnaires administered to 30 respondents selected using purposive sampling, and Fisher's Exact Test was used to analyze differences between the two groups. The results showed no significant difference in the level of knowledge between Generation Z and Millennials ($p = 0.392$). Self-medication patterns, including information sources, reasons for use, and consumption practices, were also similar between the two groups. In conclusion, generational differences did not significantly influence either the level of knowledge or the self-medication patterns related to astaxanthin use. These findings suggest that educational interventions promoting the appropriate use of dietary supplements should be directed equally toward both Generation Z and Millennials.

Keywords: Astaxanthin; Self-Medication; Generation Z; Millennials; Comparative Analysis

1. Introduction

The increase in air pollution in urban areas is one of the factors contributing to the high rate of free radical formation in the human body (1). Free radicals are unstable compounds that take electrons from other compounds, leading to oxidative stress and damage to healthy cells (2). Much of the air pollution originates from factory waste, cigarette smoke, and vehicle emissions, which are increasingly prevalent in cities (3). It is this excess of free radicals that can trigger cellular damage and subsequently a range of health problems. Under these conditions, antioxidants play an important role in neutralizing free radicals and protecting healthy cells from damage (4). Antioxidants are compounds that act as inhibitors of the oxidation process by neutralizing free radicals, thereby protecting healthy cells from oxidative stress (5). Growing public awareness of the health hazards of free radicals has driven the trend of antioxidant supplement use among Generation Z and Millennials. One widely used antioxidant is astaxanthin, a carotenoid compound with higher and superior antioxidant activity compared with vitamin C and vitamin E (6). This advantage is due to its molecular structure, which can protect the entire cell membrane layer from damage caused by free radical exposure. In addition, astaxanthin has a more stable molecule and is not easily converted into a pro-oxidant after neutralizing free radicals (7). Clinically, astaxanthin has various health benefits, including maintaining cardiovascular health, slowing premature skin

aging caused by sun exposure, reducing inflammation in acne-prone skin, and serving as an adjunct therapy for cancer patients (8). In this regard, pharmacy personnel play an important role in providing the public with appropriate education on antioxidant supplements. In addition to the rising use of supplements, easier access to information and online purchasing of health products also influences public self-medication behavior (9). Self-medication is an effort undertaken by an individual to address various health problems, or to maintain health independently, without direct consultation with a health professional (10). This practice offers benefits such as convenience, time efficiency, and cost savings; however, when carried out without adequate knowledge, it may pose risks of irrational use, such as dosage errors, incorrect timing of consumption, or interactions with other products. Therefore, sound understanding of supplement use is an important factor in supporting safe and effective self-medication (11).

Previous research on astaxanthin has generally focused on pharmacological aspects and formulation, while studies on self-medication remain general in nature and have not extensively examined differences based on generational characteristics (12). According to the classification of the Indonesian Central Statistics Agency (Badan Pusat Statistik/BPS), Millennials are the generation born between 1981 and 1996, while Generation Z is the generation born between 1997 and 2012. These two generations differ in the way they obtain and process health information. Generation Z, as digital natives, tends to be influenced by social media and visual content, whereas Millennials are more critical and tend to verify information before making decisions (13). This difference may influence understanding of the efficacy, dosage, and timing of astaxanthin supplement consumption. Community pharmacies play a strategic role as a pharmaceutical service facility that interacts directly with the public regarding the use of medicines and health supplements. Pharmacists and pharmacy personnel serve not only as product providers but also as a responsible source of information in educating the public on the rational use of supplements (14). Given the differing characteristics between generations, the educational approach provided to Generation Z and Millennials needs to be tailored so that the information conveyed can be received effectively. Nevertheless, to date no study has specifically compared the level of knowledge and self-medication behavior regarding astaxanthin use between these two generations, particularly within a community pharmacy service setting. Therefore, this study aims to analyze differences in self-medication behavior regarding astaxanthin use between Generation Z and Millennials at K-24 A Pharmacy, Bandung City, as a clinical pharmacy facility. It is hoped that the results of this study will promote the rational and appropriate use of astaxanthin supplements among the public, particularly among Millennials and Generation Z.

This study is relevant to Sustainable Development Goal 3 (SDG 3: Good Health and Well-Being) because improving health literacy and promoting the rational use of supplements are important components of safe and responsible self-medication. Understanding how different generations obtain information and use astaxanthin may help identify appropriate educational strategies to support informed decision-making, reduce inappropriate supplement use, and encourage safer self-care practices. These efforts contribute to the broader goal of improving health outcomes and promoting responsible use of health products in the community.

2. Methods

This study employed a quantitative approach with a comparative cross-sectional design and was conducted at K-24 A Pharmacy, Bandung City. The design was used to compare self-medication behavior related to astaxanthin use between Generation Z and Millennials at a single point of observation. The study population consisted of consumers who purchased or used astaxanthin supplements at the study site. The sample was selected using purposive sampling because astaxanthin users represented a specific consumer group and only respondents who met the predetermined inclusion criteria were considered eligible. A total of 30 respondents were included during the study period. The sample size was determined based on the number of eligible astaxanthin self-medication users who were accessible at the study site and fulfilled all inclusion criteria during the data-collection period. The inclusion criteria were respondents belonging to Generation Z, defined in this study as individuals born between 1997 and 2010, or Millennials, defined as those born between 1981 and 1996; respondents who had previously used or were currently using astaxanthin; and respondents who were willing to participate. Respondents who did not complete the questionnaire or did not meet the inclusion criteria were excluded. Because recruitment depended on the availability of eligible astaxanthin users, the numbers of Generation Z and Millennial respondents were not required to be equal.

The research instrument was a structured questionnaire covering respondent characteristics, knowledge regarding astaxanthin, and self-medication behavior. The knowledge variable was measured using 10 multiple-choice questions related to the purpose of astaxanthin use, recommended use, dosage and duration, possible adverse effects, precautions, interactions, appropriate sources of information, and principles of responsible supplement self-medication. Each correct answer was assigned a score of 1 and each incorrect answer a score of 0, resulting in a total possible knowledge score ranging from 0 to 10. The total score was converted into a percentage using the formula: knowledge score (%) = total correct answers/10 × 100. For categorical analysis, respondents were classified into two mutually exclusive knowledge categories. A score of 76–100%, equivalent to 8–10 correct answers, was classified as good knowledge, while a score of ≤75%, equivalent to 0–7 correct answers, was classified as sufficient knowledge. This categorization was applied consistently to all respondents before bivariate analysis. The questionnaire underwent validity and reliability testing before use in the main study.

Self-medication behavior was assessed based on the appropriateness of astaxanthin use, including the purpose of use, duration of use, and sources of information. Data were collected by administering the questionnaire directly to eligible respondents after informed consent had been obtained. Univariate analysis was used to describe respondent characteristics and the distribution of study variables. Bivariate analysis was then conducted to examine differences between Generation Z and Millennials. Because the total sample size was limited to 30 respondents and several categorical cells contained small expected frequencies, Fisher's Exact Test was used instead of the chi-square test. The relatively small purposively selected sample from a single pharmacy should be considered when interpreting the statistical findings. The unequal distribution of Generation Z and Millennial respondents reflects the actual availability of eligible astaxanthin users during the recruitment period rather than a predetermined balanced sampling allocation. Consequently, the study may have limited statistical power to detect differences between generations. Therefore, a non-significant Fisher's Exact Test result should not be interpreted as definitive evidence that no

meaningful difference exists between Generation Z and Millennials. The findings should instead be interpreted as exploratory evidence specific to the respondents included at K-24 A Pharmacy, Bandung City, and should not be generalized to the broader population of astaxanthin users without further studies involving larger and more representative samples. This study adhered to ethical principles by maintaining the confidentiality of respondent identities and obtaining informed consent prior to data collection.

3. Results and Discussion

Based on the descriptive analysis presented in Table 1, completed by 30 respondents who met the inclusion criteria, the respondent characteristics in this study were dominated by the Generation Z group (60.0%), while Millennials accounted for 40.0%. The dominance of Generation Z in this study may reflect the high level of involvement of younger age groups in the issue under study, who generally have broader access to information through digital media. In terms of sex, the majority of respondents were female (83.3%), while males accounted for only 16.7%. This indicates a higher tendency for participation among females, which in several studies is often associated with a greater level of concern for health-related matters or specific areas of knowledge.

The respondents' level of knowledge was predominantly in the good category (76.7%), while the sufficient category accounted for only 23.3%. These findings indicate that, in general, respondents had an adequate understanding of the research topic. This relatively high level of knowledge may be influenced by ease of access to information, particularly among Generation Z, who are known to be adaptive to technology and digital information sources.

Table 1. Respondent characteristics

Variable	Category	Number (n)	Percentage (%)
Generation	Generation Z	18	60.0
	Millennials	12	40.0
Sex	Female	25	83.3
	Male	5	16.7
Knowledge	Sufficient	7	23.3
	Good	23	76.7

Based on the survey results for the 30 respondents, consisting of 18 Generation Z respondents (60.0%) and 12 Millennial respondents (40.0%), most respondents obtained information from social media and advertisements (50.0%), followed by health professionals (43.3%), and friends or family (6.7%). These results indicate that social media has a substantial influence on respondents' knowledge regarding astaxanthin self-medication; in addition, health professionals remain an important and widely trusted source of knowledge among respondents.

The main purpose of astaxanthin use was predominantly as a supplement to maintain skin health (63.3%). This result indicates that benefits related to appearance and skin health are the primary reasons influencing respondents' interest in consuming astaxanthin. The

survey results regarding duration of consumption showed that most respondents consumed astaxanthin irregularly (63.3%), indicating that although there is interest in astaxanthin use, consumption tends to be discontinuous among both Generation Z and Millennial respondents. This is influenced by several factors, including level of knowledge, perceived benefits, supplement consumption habits, and cost considerations.

Table 2. Association between generation and astaxanthin self-medication patterns (Fisher's Exact Test)

Variable	Category	Gen Z n (%) (n=18)	Millennials n (%) (n=12)	Total n (%) (n=30)	p-value
Information Source	Social media & advertisements	11 (61.1)	4 (33.3)	15 (50.0)	0.218
	Health professionals	6 (33.3)	7 (58.3)	13 (43.3)	
	Friends/Family	1 (5.6)	1 (8.4)	2 (6.7)	
Purpose of Consumption	Skin health	13 (72.2)	6 (50.0)	19 (63.3)	0.547
	Antioxidant	4 (22.2)	4 (33.3)	8 (26.7)	
	Immune support	1 (5.6)	2 (16.7)	3 (10.0)	
Duration of Consumption	Irregular (< 1 month)	12 (66.7)	7 (58.3)	19 (63.3)	0.681
	< 3 months	4 (22.2)	2 (16.7)	6 (20.0)	
	1-3 months	2 (11.1)	3 (25.0)	5 (16.7)	

Note: significance level $\alpha = 0.05$; $p\text{-value} > 0.05 \rightarrow$ no significant association.

Although Fisher's Exact Test showed no statistically significant association between generational group and source of information on astaxanthin ($p = 0.218$), the descriptive distribution suggests a potentially relevant difference in information-seeking patterns. Generation Z respondents more frequently reported obtaining information from social media and advertisements, whereas Millennials more often reported healthcare professionals as their source of information. This pattern may reflect broader generational differences in media use and access to health information, with younger consumers tending to rely more heavily on digital platforms and promotional content, while older consumers may be more likely to seek information from professional or interpersonal sources. From a practical perspective, this descriptive difference is important because the quality and reliability of information obtained through social media or advertising can vary considerably. Consumers who rely primarily on digital promotional content may be more exposed to incomplete, exaggerated, or commercially oriented claims regarding the benefits, dosage, and safety of astaxanthin. In contrast, information obtained from healthcare professionals is more likely to include individualized advice regarding indications, appropriate use, possible adverse effects, interactions, and the need to avoid unnecessary or inappropriate supplementation.

Therefore, even though the difference did not reach statistical significance, the observed pattern may still have implications for health-education strategies. For Generation

Z, educational interventions could prioritize evidence-based digital communication through social media, pharmacy platforms, and other online channels frequently used by younger consumers. For Millennials, counseling by pharmacists and other healthcare professionals may remain an important approach. However, because the present study involved only 30 respondents from a single pharmacy and had limited statistical power, these descriptive differences should be interpreted cautiously and should not be considered evidence of a definitive generational difference. Larger studies are needed to determine whether the observed pattern persists in broader and more representative populations.

Table 3. Association of generation with knowledge level (Fisher's Exact Test)

Statistical Test	<i>p-value</i>	Description
<i>Fisher's Exact Test</i>	0.392	Not Significant
Sample Size (n)	30	

Note: significance level $\alpha = 0.05$; $p\text{-value} > 0.05 \rightarrow$ no significant association.

The absence of a significant difference may be attributable to several factors. First, there is homogeneity in access to information between the two generational groups, particularly given technological developments that enable a more equitable distribution of information. Second, factors such as educational background and social environment, which may be relatively similar among respondents, could also contribute to the lack of a significant difference in knowledge level. In addition, the relatively small sample size ($n = 30$), resulting from the limited number of respondents meeting the inclusion criteria, may have affected the statistical power to detect differences. Overall, the results of this study indicate that both Generation Z and Millennials have a relatively good and comparable level of knowledge. Therefore, interventions or strategies to improve knowledge can be designed generally, without the need for specific differentiation based on generational group. Nevertheless, these findings should be considered in light of several limitations. The relatively limited sample size ($n = 30$) may affect the statistical power to detect significant differences and may limit the generalizability of the study results. In addition, the unbalanced distribution of respondents by sex, with a predominance of females, may affect the representativeness of the findings. Furthermore, the use of a self-report questionnaire may introduce subjective bias among respondents.

The questionnaire used in this study underwent validity and reliability testing before being administered to the main study participants. The instrument consisted of 15 items, including 10 items assessing knowledge of astaxanthin and appropriate self-medication and 5 items assessing self-medication behavior, including purpose of use, duration of use, source of information, and appropriateness of supplement use. The preliminary instrument was tested on 30 respondents who had characteristics similar to those of the target population, namely adult consumers who had previously used or were currently using astaxanthin supplements. These respondents were recruited outside the main study sample and were not included among the final 30 respondents analyzed in the study. Item validity was assessed using the Pearson Product-Moment correlation between each item score and the total score. An item was considered valid when the calculated correlation coefficient ($r\text{-count}$) was greater than the critical $r\text{-table}$ value at a significance level of 0.05. With 30 respondents, the reference

r-table value was 0.361. The validity analysis showed that all questionnaire items had r-count values exceeding 0.361 and were therefore considered valid and retained for use in the final instrument. Instrument reliability was assessed using Cronbach's alpha to determine internal consistency. The overall Cronbach's alpha coefficient was 0.82, indicating good internal consistency. The knowledge-item component had a Cronbach's alpha of 0.80, while the self-medication behavior component had a coefficient of 0.78. Based on the commonly applied criterion of Cronbach's alpha ≥ 0.70 , both components were considered sufficiently reliable for use in the main study. Following completion of the validity and reliability testing, the finalized questionnaire was administered to the 30 eligible respondents included in the comparative analysis between Generation Z and Millennials.

The findings of this study indicate that self-medication practices involving astaxanthin among Generation Z and Millennials were generally similar based on the statistical analyses; however, several descriptive patterns deserve further consideration. In particular, Generation Z respondents more frequently reported obtaining information about astaxanthin from social media and advertisements, whereas Millennials more often reported healthcare professionals as their source of information. Although this difference was not statistically significant, it is consistent with previous research showing that Generation Z tends to rely more heavily on internet-based and social-media sources for health information. A cross-sectional study involving 1,862 respondents found that Generation Z was significantly more likely than older groups to use the internet, social media, and search engines for health-related information, while older generations relied more on interpersonal and traditional sources. This generational pattern is particularly relevant in the context of dietary supplements because online information may influence consumer perceptions of product benefits, safety, and necessity. A systematic review and meta-analysis on health literacy in dietary supplement use found that health literacy was associated with supplement-consumption behavior among working-age adults. Another empirical study also demonstrated that awareness of dietary supplement advertising and health literacy were significantly associated with health behavior, suggesting that exposure to promotional information can influence how consumers evaluate and use supplements. Therefore, the higher descriptive reliance of Generation Z on social media and advertisements should not automatically be interpreted as inappropriate behavior, but it highlights the importance of assessing the credibility and quality of the information used to support self-medication decisions.

The findings should also be considered in relation to self-medication behavior more broadly. Previous outpatient research demonstrated a significant relationship between health literacy and self-medication practices, indicating that consumers with different levels of health literacy may differ in their ability to access, understand, and appropriately apply health information. In Indonesia, research on dietary supplement consumption similarly showed that although many adults had relatively good general knowledge, important gaps remained regarding adverse effects and potential drug-supplement interactions. These findings are relevant to astaxanthin because consumers may perceive antioxidant supplements as inherently safe while paying less attention to appropriate dosage, duration of use, contraindications, or possible interactions. From the perspective of community-pharmacy practice, the present findings highlight an opportunity for pharmacists to act as an accessible source of evidence-based information. A systematic review of community pharmacists' practices regarding complementary medicines and dietary supplements found that pharmacists commonly encounter consumers using vitamins, minerals, herbal products, and

dietary supplements, but counseling practices are not always consistent. Lack of reliable information and insufficient professional training were identified as barriers to optimal counseling. This suggests that community pharmacists should not limit their role to supplying supplements but should actively assess the consumer's reason for use, existing medications, duration of consumption, expectations of benefit, and source of information.

For Generation Z consumers, community pharmacies may benefit from combining face-to-face counseling with credible digital health communication. Pharmacists could provide concise evidence-based information through pharmacy social-media accounts, QR-linked educational materials, or other digital channels that are commonly accessed by younger consumers. For Millennials, who in this study more frequently reported healthcare professionals as information sources, direct pharmacist counseling may remain particularly important. Such strategies may help reduce dependence on promotional claims while strengthening responsible self-medication and health literacy. Nevertheless, these descriptive patterns should be interpreted cautiously. The present study involved only 30 purposively selected respondents from one pharmacy, and the generational groups were not equally distributed. Therefore, the observed differences in information sources should not be regarded as definitive evidence of generational behavior. Rather, they represent exploratory patterns that may be useful for designing more targeted pharmacy-based health education and should be examined further in larger, multicenter studies with more balanced generational samples.

Based on the limitations identified in this study, several recommendations can be proposed for future development:

1. For Future Researchers: It is recommended that further research be conducted using a larger and more representative sample size (n), employing a stronger research design to minimize subjectivity bias, and considering other relevant variables in order to obtain a more comprehensive picture of self-medication behavior.
2. For Pharmacy Practitioners/Pharmacies: Given that knowledge-improvement strategies or educational interventions do not need to be specifically differentiated by generational group, pharmacy personnel can design IEC (Information, Education, and Communication) programs on the safe and rational use of supplements, delivered generally and equally to all community groups.

Conclusions

Based on the results of this study on the comparative analysis of knowledge and self-medication patterns of astaxanthin supplements at K-24 A Pharmacy, Bandung City, it can be concluded that (i) There was no statistically significant difference or association between generational group and level of knowledge regarding astaxanthin ($p = 0.392$; $p > 0.05$). Both Generation Z and Millennials had a comparable level of knowledge, with the majority in the good category (76.7%). (ii) The astaxanthin self-medication pattern among Generation Z and Millennials showed similar tendencies based on the results of Fisher's Exact Test, in terms of information source ($p = 0.218$), purpose of consumption ($p = 0.547$), and duration of consumption ($p = 0.681$). The majority of respondents in both generational groups obtained information from social media and advertisements, consumed the supplement to maintain skin health, and had irregular consumption habits. (iii) Generational differences between Millennials and Generation Z did not affect the level of understanding or the self-medication behavior related to astaxanthin supplement use in the community.

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Conflicts of Interest

The authors declare no conflict of interest.

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