SYSTEMATIC REVIEW

The Prevalence of Online Natural Health Products Purchase: A Systematic Review

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ABSTRACT

Aim and design: This systematic review aimed to estimate the prevalence of online natural health products (NHPs) purchases among consumers. Data Sources: Four databases (PubMed, Science Direct, Scopus and Web of Sciences) were searched for articles published up to July 1, 2021. Review Method: Studies included were those reporting the prevalence of online NHPs purchases, those excluded were case reports, commentaries, letters, editorials, review articles, theses and non-English studies. The risk of bias of selected studies was assessed using the Joanna Briggs Institute’s checklist, and the pooled prevalence of online NHPs purchases was generated using the random-effect model. Results: A total of 30 studies were included in the meta-analysis, representing a total of 40,535 respondents. The pooled prevalence of online NHPs purchases was estimated at 7.60% (95% CI: 5.49, 10.01). Prevalence was higher in studies conducted in recent years, among physically active populations and when sports nutrition was included within the scope of NHPs. More than half of the selected studies have a moderate risk of bias, and considerable heterogeneity was observed across the selected studies. Conclusion and Impact: Online purchases of NHPs are not common among consumers, but they have become more common in recent years. A wide range of NHPs were investigated across studies, which may have contributed to the considerable heterogeneity reported in this review. It is suggested that future studies investigating online NHPs purchases consider reporting individual prevalence statistics specific to each NHP type, to facilitate meaningful comparisons between studies.

Keywords: Online purchase, Natural health product, Dietary supplement, Complementary and alternative medicine

INTRODUCTION

Natural health products (NHPs) are widely used to supplement one’s diet and to enhance one’s health functions, particularly in this era when people are becoming more involved in their health care (1). In the US, 57.6% of their adults use dietary supplements with an increase in supplement use observed across all age groups over the last decade (2-4). Notably, the NHPs industry is generating revenue and its global market is expected to expand in the approaching years (5). Such growth could be attributed to a rise in interest in natural substances, which were thought to be safer and have fewer side effects than medication (5,6).

Many NHPs are available without a prescription and are frequently self-selected by the general public. However, not all NHPs are evaluated for safety and efficacy before they are marketed; on the other hand, many of them are regulated through post-market surveillance (7). In the other words, the consumers are responsible for their NHPs selection without much pre-market authorization undertaken by the regulators. On top of that, since NHPs contain biologically active substances, improper use of NHPs may also result in unwanted side effects or interactions with other medications (8,9).

With the advancement of information technology and the introduction of e-commerce, NHPs are no longer restricted to physical stores but is also freely accessible via the Internet. Moreover, the recent COVID-19 pandemic has further escalated the online sales of pharmaceutical and health-related products, resulting from the continuous movement restriction which compels consumers to shift from physical to online shopping (10). Besides, a higher perceived infection risk among consumers also propels them towards NHPs use (11). The prevalence of online NHPs purchases is thus expected to rise during this pandemic era.

Although NHPs use among consumers has been widely explored, the magnitude of online NHPs purchasing varies. Hence, this study aimed to review the prevalence
of online NHPs purchases among consumers.

METHODOLOGY

This systematic review was registered with PROSPERO (ID: CRD42020222321) and the National Medical Research Register of Malaysia (NMRR-20-2250-56889 (IIR)). The reporting of study findings was in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (12).

Search of literature
Published articles were searched via electronic databases, including PubMed, Science Direct, Scopus and Web of Sciences, from inception to November 2020, followed by an update search conducted on July 1, 2021. The document type was limited to ‘Article’ when searching on Science Direct and Web of Science. The search strategy combined keywords and terms related to online purchase (e.g., internet purchase, online shopping) and NHPs (e.g., dietary supplement, traditional and complementary medicine). Additionally, relevant studies were manually identified by screening through the reference lists of included articles.

Eligibility criteria
In this review, NHPs may contain one or more of the following ingredients: probiotics, herbal remedies, vitamins and mineral, homeopathic medicines, traditional medicines and other products (e.g., amino acids and essential fatty acids) (13). Only orally administered NHPs were included in this study. On the other hand, this review defined ‘online purchase’ as the activity of obtaining NHPs over the Internet, regardless of the platform used or method of transaction that was involved. Since this review was to provide a general overview of online NHPs purchases across the board, studies involving any group of consumers were considered for review.

Included studies were those published in a peer-reviewed journal and those reporting the prevalence of online NHPs purchases or could be calculated from available data. Studies that combined sports nutrition (e.g., protein powder, sports drinks/bars) with NHPs were considered for further review as ‘sports nutrition’ was considered as a type of product that was intended to supplement an individual’s diet. Studies excluded were case reports/series, commentaries, letters, editorials, review articles, theses, and studies that were published in languages other than English. Studies that combined over-the-counter medication, cosmetics or non-orally administered products with NHPs were also excluded from further review.

Selection process
The titles and abstracts of records returned from the search were deduplicated. One review author assessed the study titles and abstracts, those that were irrelevant to this review were removed. Subsequently, the full texts of the remaining studies were independently evaluated by two review authors. Any disagreements on the study eligibility were resolved by discussion, while a third review author was involved for arbitration if a disagreement remained unresolved.

Data extraction
Data were extracted from selected studies using an Excel spreadsheet by a review author and later independently verified by second and third review authors to minimize bias and error. Information extracted were study details (author, year of study inception, country where the study was conducted, study design), respondents (sample size, demographics, number of NHPs users), types of product studied (whether sports nutrition was included as part of NHPs), study instrument used and the number of respondents reported online NHPs purchase. The count of respondents who purchased NHPs over the Internet was either acquired from the articles, calculated from available data, or extracted from presented graphs. The study sample size was taken as the denominator in the estimation of prevalence value. In order to resolve data-related uncertainties or missing information, the original authors were contacted via email to a maximum of three attempts.

Risk of bias assessment
The quality of studies was independently assessed by two review authors using the critical appraisal tools from Joanna Briggs Institute (JBI) for prevalence studies (9 criteria) (14). For each study, the risk of bias was categorized based on the percentage of criteria met (indicated by a ‘yes’ response for a criterion): high risk (≤49%), moderate risk (50-69%) or low risk (≥70%) (15).

Data analysis
In the meta-analysis, the prevalence of online NHPs purchases was pooled by employing the Freeman-Tukey transformation. Since diverse population groups and types of products were expected in this review, the random-effects model was used in meta-analysis. The 95% confidence interval (CI) was generated for each data of prevalence and no imputation was performed for missing data.

Heterogeneity across studies was evaluated using the $F$ statistics ($F > 75\%$ suggesting considerable heterogeneity) and the chi-squared test, with a $p$-value < 0.1 deemed significant (16). Subgroup analyses were performed to explore the possible sources of heterogeneity. The possibility of publication bias was assessed by visual inspection of the funnel plot as well as the Egger’s test, with statistical significance considered when $p < 0.05$. To assess the stability of pooled prevalence, sensitivity analysis was performed by removing studies with a high risk of bias from the analysis. Statistical analyses were performed using the MedCalc® Statistical Software version 20.009 (MedCalc Software Ltd, Ostend, Belgium).
The quality of pooled prevalence was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework (17) by two reviewers independently in duplicate. Since the selected studies were observational in design, the quality of evidence started as ‘low’ and was modified downward based on the following criteria: (1) selected studies have important risk of bias, (2) inconsistency (considerable heterogeneity across studies), (3) indirectness (limited generalizability of findings), (4) imprecision (small number of events or wide 95% CI for pooled prevalence), (5) publication bias.

RESULTS

Search of literature
A total of 17,373 records were obtained from the literature search and the full-text articles of 287 studies were reviewed for eligibility. The studies removed (n=257) were reports (n=5), reviews (n=15), commentaries (n=1), those that were irrelevant to this review (n=219), published in languages other than English (n=6), not presenting usable data (n=1) or the surveyed product included medication, non-oral products or cosmetic (n=10). A final 30 studies were selected in this review (Fig. 1).

Characteristics of selected studies
The 30 studies included in this review represented a total of 40,535 respondents, of which 9,438 NHPs users were identified in 27 studies, while this information was not reported in the other three studies (Table I). Half of these studies recruited respondents from the Europe (n=16) (18-33), followed by Asia (n=6) (34-39), Middle East (n=3) (40-42), Northern America (n=3) (43-45), Oceania (n=1) (46) and one study involved respondents from 21 different nationalities (47). The majority of these studies (n=27) (18-30,32-42,44,46,47) were conducted within the last decade, except for three conducted between the late 1990s and before 2010 (31,43,45).

Ten studies reported online purchase of NHPs among patients(18-20,23,24,26,30,33,40,43), seven among the general public (21,32,34,35,42,44,46), while a few among athletes (n=4)(25,29,31,47), caregivers of children (n=3)(27,36,38), and two each among pregnant women (22,45), students (37,39) and fitness centre members (28,41). Online purchase of NHPs was collectively reported as any product sourced from the “Internet” or “online” in all studies, and one study included the purchase of the product by another person from abroad as part of the online purchase as well (38). Otherwise, none of these studies define the platform or process of online purchase in specific. Most studies covered a combination of products, including vitamins, minerals, probiotics, fish oil and/or herbal and traditional medicinal products, except seven studies that only focused on herbal and traditional medicinal products (e.g., honey and saiga horn) (18-20,23,24,34,35). Notably, six studies also included sports nutrition (e.g., protein powder, energy drinks/bars) as part of NHPs (25,28,29,31,41,47).

Quality assessment of selected studies
Included studies were evaluated based on the JBI checklist for prevalence, four of them had a low risk of bias (13.3%), 20 had a moderate risk of bias (66.7%), while six had a high risk of bias (20.0%).

Prevalence of online NHPs purchase
The prevalence of online NHPs purchases ranged from 0% to 37.1% across 30 studies, with a pooled prevalence estimated at 7.60% (95% CI: 5.49, 10.01) (Fig. 2). As considerable heterogeneity was observed ($I^2 = 98.2\%, p<0.001$), the use of random-model effects was thus justified. Possible sources of heterogeneity were explored by performing subgroup analyses (Table II). However, heterogeneity did not appear to be lower within subgroups, except for the pregnant woman ($I^2 = 0\%, p=0.35$) and student subgroups ($I^2 = 0\%, p=0.51$). Due to the small number of studies contributed in these subgroups (two studies in each subgroup), this finding ought to be interpreted with caution.

Subgroup analyses
Studies undertaken between 2016 to 2020 demonstrated a higher prevalence of online NHPs purchase among the overall population (9.48% [95% CI: 6.40, 13.08]) than those conducted earlier (5.57% [95% CI: 2.52, 9.70]) (Table II). When considering different populations, online NHPs purchase was more prevalent among the
Table I: Characteristics of selected studies (sorted by inception year of study)

<table>
<thead>
<tr>
<th>Study ID</th>
<th>Country (Continent)</th>
<th>Inception year of study</th>
<th>Study design, setting</th>
<th>Population</th>
<th>Inclusion of sports nutrition in NHPs</th>
<th>Method of measurement</th>
<th>Sample Size</th>
<th>NHPs User</th>
<th>Online NHPs purchase Prevalence [95% CI] (%)</th>
<th>Risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tsui B et al 20</td>
<td>California (Northern America)</td>
<td>1999</td>
<td>Cross-sectional, academic medical facility</td>
<td>Pregnant woman</td>
<td>No</td>
<td>Questionnaire</td>
<td>150</td>
<td>20</td>
<td>2</td>
<td>1.33 (0.16, 4.73)</td>
</tr>
<tr>
<td>2. Gobert et al 21</td>
<td>Canada (Northern America)</td>
<td>2005†</td>
<td>Cross-sectional, community</td>
<td>Patient (Type 2 diabetes)</td>
<td>No</td>
<td>Questionnaire</td>
<td>200</td>
<td>145</td>
<td>0°</td>
<td>0.00 (0.00, 1.83)</td>
</tr>
<tr>
<td>3. Tsarouhas et al 22</td>
<td>Greece (Europe)</td>
<td>2008°</td>
<td>Cross-sectional, gym</td>
<td>Athlete (Recreational adolescent athlete)</td>
<td>Yes</td>
<td>Questionnaire</td>
<td>170</td>
<td>100</td>
<td>63</td>
<td>37.06 (29.79, 44.79)</td>
</tr>
<tr>
<td>5. Graham-Paulson et al 24</td>
<td>USA, Germany, Switzerland, (Multi-national)</td>
<td>2012</td>
<td>Cross-sectional, athletic training/ competition</td>
<td>Athlete (physical/ visually impaired)</td>
<td>Yes</td>
<td>Questionnaire</td>
<td>399</td>
<td>232</td>
<td>67</td>
<td>16.79 (13.26, 20.83)</td>
</tr>
<tr>
<td>6. Mazzeto et al 25</td>
<td>Italy (Europe)</td>
<td>2012</td>
<td>Cross-sectional, sport's club</td>
<td>Athlete (Competitor &amp; non-competitor boxer)</td>
<td>Yes</td>
<td>Questionnaire</td>
<td>169</td>
<td>117</td>
<td>1</td>
<td>0.59 (0.02, 3.25)</td>
</tr>
<tr>
<td>7. Soner et al 26</td>
<td>Turkey (Europe)</td>
<td>2012</td>
<td>Cross-sectional, hospital</td>
<td>Patient (Inpatient and outpatient)</td>
<td>No</td>
<td>Structured interview</td>
<td>927</td>
<td>452</td>
<td>27</td>
<td>2.91 (1.93, 4.21)</td>
</tr>
<tr>
<td>8. Akguz et al 27</td>
<td>Turkey (Europe)</td>
<td>2013</td>
<td>Cross-sectional, hospital</td>
<td>Patient (Cardiology)</td>
<td>No</td>
<td>Questionnaire</td>
<td>390</td>
<td>116</td>
<td>11</td>
<td>2.82 (1.42, 4.99)</td>
</tr>
<tr>
<td>9. Abd Wahab et al 28</td>
<td>Malaysia (Asia)</td>
<td>2014†</td>
<td>Cross-sectional, community</td>
<td>General public</td>
<td>No</td>
<td>Questionnaire</td>
<td>300</td>
<td>168</td>
<td>12</td>
<td>4.00 (2.08, 6.88)</td>
</tr>
<tr>
<td>10. AlRuthia et al 29</td>
<td>Saudi Arabia (Middle East)</td>
<td>2015</td>
<td>Cross-sectional, fitness centre</td>
<td>Fitness centre member (Male)</td>
<td>Yes</td>
<td>Structured interview</td>
<td>445</td>
<td>198</td>
<td>56</td>
<td>12.58 (9.65, 16.03)</td>
</tr>
<tr>
<td>11. Adam et al 30</td>
<td>Poland (Europe)</td>
<td>2015</td>
<td>Cross-sectional, oncology centre</td>
<td>Patient (Oncology)</td>
<td>No</td>
<td>Survey</td>
<td>92</td>
<td>75</td>
<td>2</td>
<td>2.17 (0.26, 7.63)</td>
</tr>
<tr>
<td>12. Cabut et al 31</td>
<td>France (Europe)</td>
<td>2015</td>
<td>Cross-sectional, pharmacy &amp; clinic</td>
<td>Pregnant woman</td>
<td>No</td>
<td>Questionnaire</td>
<td>68</td>
<td>15</td>
<td>0</td>
<td>0.00 (0.00, 5.28)</td>
</tr>
<tr>
<td>13. Bellikci-Kuyu et al 32</td>
<td>Turkey (Europe)</td>
<td>2015</td>
<td>Cross-sectional, hospital</td>
<td>Patient (Overweight/ obese)</td>
<td>No</td>
<td>Structured interview</td>
<td>464</td>
<td>112</td>
<td>7</td>
<td>1.51 (0.61, 3.08)</td>
</tr>
<tr>
<td>14. Mengelberg et al 33</td>
<td>New Zealand (Oceania)</td>
<td>2015</td>
<td>Cross-sectional, community</td>
<td>General public</td>
<td>No</td>
<td>Questionnaire</td>
<td>334</td>
<td>296</td>
<td>38</td>
<td>10.98 (7.89, 14.76)</td>
</tr>
<tr>
<td>15. Kobayashi (a) et al 34</td>
<td>Japan (Asia)</td>
<td>2016</td>
<td>Cross-sectional, community</td>
<td>Student (College)</td>
<td>No</td>
<td>Questionnaire</td>
<td>9066</td>
<td>2060</td>
<td>404</td>
<td>4.46 (4.04, 4.90)</td>
</tr>
<tr>
<td>16. Bowman et al 35</td>
<td>Malta (Europe)</td>
<td>2017</td>
<td>Cross-sectional, community</td>
<td>General public</td>
<td>No</td>
<td>Questionnaire</td>
<td>444</td>
<td>NR</td>
<td>36°</td>
<td>8.11 (5.74, 11.05)</td>
</tr>
<tr>
<td>17. Almuhareb et al 36</td>
<td>Saudi Arabia (Middle East)</td>
<td>2017</td>
<td>Cross-sectional, hospital</td>
<td>Patient (Rheumatoid arthritis)</td>
<td>No</td>
<td>Structured interview</td>
<td>438</td>
<td>292</td>
<td>5</td>
<td>1.14 (0.37, 2.64)</td>
</tr>
<tr>
<td>18. Ruano et al 37</td>
<td>Portugal (Europe)</td>
<td>2017†</td>
<td>Cross-sectional, gym association</td>
<td>Fitness centre member</td>
<td>Yes</td>
<td>Questionnaire</td>
<td>459</td>
<td>201</td>
<td>113</td>
<td>24.62 (20.74, 28.83)</td>
</tr>
<tr>
<td>19. Dougherty et al 38</td>
<td>Singapore (Asia)</td>
<td>2017</td>
<td>Cross-sectional, community</td>
<td>General public (Chinese)</td>
<td>No</td>
<td>Questionnaire &amp; structured interview</td>
<td>2294</td>
<td>438</td>
<td>0</td>
<td>0.00 (0.00, 0.16)</td>
</tr>
<tr>
<td>21. Kobayashi (b) et al 40</td>
<td>Japan (Asia)</td>
<td>2017</td>
<td>Cross-sectional, community</td>
<td>Caregiver of children (Mother whose children use(d) NHPs)</td>
<td>No</td>
<td>Questionnaire</td>
<td>19,041</td>
<td>2439</td>
<td>990</td>
<td>5.20 (4.89, 5.52)</td>
</tr>
</tbody>
</table>
fitness centre members (18.29% [95% CI: 8.13, 31.39]), athletes (17.95% [95% CI: 4.61, 37.45]), and children’s caregivers (12.87% [95% CI: 2.99, 28.23]) than the other subgroups. When sports nutrition was covered in the category of NHPs, the prevalence of online purchase (18.06% [95% CI: 9.30, 28.92]) was higher than those studies that did not include sports nutrition as part of NHPs (5.67% [95% CI: 3.88, 7.76]).
Publication bias, sensitivity analysis and quality of evidence

The funnel plot (Fig. 3) of the prevalence of online NHPs purchases did not suggest any evidence of publication bias (Egger’s test, \( p = 0.15 \)). When sensitivity analysis was conducted by excluding studies with a high risk of bias, the resulting pooled prevalence of online NHPs purchase was 8.23%, [95% CI: 5.96, 10.84]), which was higher than the main result (7.60%). Such marginal difference suggests that the main result was stable and not excessively influenced by those studies with a high risk of bias. Based on the GRADE assessment, the quality level of the pooled prevalence was downgraded from low to very low due to the presence of inconsistency across studies.

![Funnel plot for the prevalence of online NHPs purchase in the overall population.](image)

**DISCUSSION**

This review shows that seven in 100 people had purchased NHPs over the Internet. Previous literature revealed that online purchase of NHPs is not as prevalent as other products, such as apparel and furniture (48). Such variation in prevalence could be associated with the product characteristics of NHPs, the quality of which could not be determined before purchase, unlike apparel and furniture (49). As a result, consumers are generally more hesitant to acquire this type of product over the Internet (50). However, the subgroup analysis revealed that online NHPs purchases have increased in recent years compared to previous years. This could be attributed to the advancing information technology and e-commerce ecosystem over the years that facilitate the growth of online purchase (51), as well as an ageing population seeking wellness and increasing interest towards natural substances (5). Nevertheless, NHPs are health-related product and its online sales should not be treated the same as the other fashion and hardware products. It is noteworthy that unmonitored and inappropriate NHPs use could result in adverse drug-supplement interaction or toxicity (52,53). This review calls for attention from the authorities in fostering stricter and more regulated online NHPs sales to safeguard the public’s health.

The subgroup analyses showed that both fitness centre members and athletes marked the highest prevalence of online NHPs purchase than other subgroups of consumers. Both of these subgroups are physically active, and in addition to health purposes, they consume NHPs to accelerate physical recovery, improving athletic performance and muscle mass (28,54,55). As a result, they use a greater spectrum of NHPs, particularly including sports nutrition on top of vitamins and minerals. This may explain why the prevalence of online NHPs purchases is evidently higher when sports nutrition was included under the scope of NHPs. In the context of consumer’s safety, product authenticity is a common concern across all types of NHPs. Furthermore, sports nutrition has an additional risk of being adulterated with ergogenic and anabolic substances, due to its intended purpose to enhance physical performance (56). A study conducted in the Dutch market has reported that 38% of sports-related NHPs sampled online contained undeclared doping substances, ranging from stimulant, anabolic steroid, beta-2-agonist to beta-blocker (56). Given the higher prevalence of online NHPs purchases among physically active subgroups, the risk of acquiring adulterated NHPs from online purchases should be adequately conveyed to this community.

Following the physically active subgroups, online NHPs purchase was also common among child caregivers. NHPs that was commonly provided to children included vitamin C, probiotics/prebiotics, calcium and iron (27,36), aiming to improve the children’s overall health, immune system and bone health (57). Studies found that caregivers who consume NHPs are more likely to provide NHPs to their children (27,57), highlighting an important point that children’s NHPs use is primarily dependent on their caregiver’s decision. When NHPs is easily accessible to the caregivers through the e-commerce platforms, their capacity to make an informed and prudent NHPs selection for their children is critical. Moreover, some caregivers do not have proper guidance in NHPs selection (38,57), which necessitate more communication between healthcare professionals and caregivers, facilitating the conversation about the use of NHPs on their children, and serving as a credible reference point for the caregivers.

When comparing between types of products, a higher prevalence of online purchase was noted when sports nutrition was investigated along with other types of NHPs. This could be due to the study population involved, as studies including sports nutrition for exploration were conducted among physically active subgroups, notably athletes and fitness centre members, who have recorded a higher prevalence of online NHPs purchase than other populations. However, due to the lack of individual prevalence for online purchase of each NHPs type, this
review is unable to establish that the high prevalence of online NHPs purchase among physically active subgroups was influenced by the online sports nutrition purchase. This review consequently suggests that future studies investigating online NHPs purchases consider reporting individual prevalence statistics specific to each NHP type, to allow meaningful comparison between studies.

Strength and Limitation
To the best knowledge of the researchers, this is the first systematic review reporting the pooled prevalence of online NHPs purchases for the general population. The meta-analysis covered a large number of respondents from studies that were mostly of low to moderate risk of bias, and no risk of publication bias was identified. However, high heterogeneity exists across the selected studies and remained unexplained by the subgroup analysis. This may be due to the vast and diverse spectrum of NHPs investigated across studies, as well as the unstandardized reporting time frame and instrument used to capture the activity of online NHPs purchase. Furthermore, the variables examined in the subgroup analyses may not encompass the variables impacting the prevalence of online NHPs purchases. Nevertheless, this review provides an insight into the magnitude of online NHPs purchase among the consumer, and a preliminary comparison of such activities across subgroups.

CONCLUSION
The online purchase of NHPs occurred at the prevalence of 7.6%. Comparison between limited numbers of studies suggested that online NHPs purchase was more prevalent in recent years, among physically active populations and when sports nutrition was included within the scope of NHPs. However, a larger number of studies are required to be conclusive. A wide range of NHPs were investigated across studies, which may have contributed to the high heterogeneity reported in this review. It is recommended that future studies investigating online NHPs purchases consider reporting individual prevalence statistics specific to each NHP type, to allow meaningful comparisons between studies.

ACKNOWLEDGEMENT
The authors would like to thank the Director-General of Health Malaysia for permission to publish this article. We also acknowledge the guidance and support given by Dr. Renly Lim in the current study.

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