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Malacca Pharmaceutics

Vol. 2, No. 1, 2024

Probiotics and Their Role in Decreasing Diarrhea Prevalence in the Elderly Population: A Comprehensive Meta-Analysis

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Article History

Received 7 January 2024
Revised 27 February 2024
Accepted 8 March 2024
Available Online 14 March 2024

Keywords:
Microbial supplements
Gastrointestinal disorder
Geriatric

Abstract

Diarrhea is an atypical state of the digestive system characterized by a soft or watery texture in bowel movements. Antibiotic-related diarrhea is common in the elderly due to extensive antibiotic use. Probiotics are vital microorganisms that support the intestinal flora and reduce bacterial colonization in the intestinal wall. This study aimed to assess the effectiveness, type, and dose of probiotics for diarrhea in the elderly. A systematic review with meta-analysis was conducted using PubMed, ScienceDirect, and Google Scholar. Seven records with a total of 2,087 participants were included. A quantitative analysis was carried out using Review Manager version 5 software. A meta-analysis was conducted to assess the frequency of diarrhea. The results showed that using probiotics significantly reduced the risk of antibiotic-related diarrhea 0.53 times compared to the placebo administration (OR 0.53; CI 95% 0.29 to 0.98; I2 = 70%). The type of probiotics frequently given was the genera of *Lactobacillus, Bifidobacterium*, and *Streptococcus,* with consumption durations varying from 3 days to a maximum of 4 weeks. The dose of probiotics ranged from a minimum of 1.0×10^6 CFU to a maximum dose of 2×10^{10} CFU. To conclude, probiotic administration is more effective than placebo in reducing the risk of antibiotic-related diarrhea in the elderly.

1. Introduction

Diarrhea is an abnormal condition of defecation, occurring three or more times a day and characterized by a mushy or liquid consistency, sometimes manifesting as mostly water [1, 2]. Diarrhea is a global health problem, especially in developing countries, including Indonesia, in which a high incidence of diarrhea in terms of mortality and morbidity remains one of the health problems demanding serious management [3]. Diarrhea can affect individuals of all age groups, including toddlers, children, adults, and even the elderly. Health problems in the elderly often arise from a decline in the function of body organs, leading to diminished energy and digestive capacity, typically starting around the age of 50 [4]. The alteration in gut microflora in the elderly is associated with a reduction in nonpathogenic bacteria (i.e., *Lactobacillus* and *Bifidobacterium*) and an increase in potentially pathogenic species. These changes generally result in gastrointestinal disorders and infections [5].

World Health Organization (WHO) data shows that there are 2 billion cases of diarrhea in adults and about 2.5 million cases of death every year due to diarrhea around the world. The national mortality data study from Indonesia reported that there were more than 28,000 deaths from diarrhea within nine years, with 51% of deaths occurring in the elderly [6]. Diarrhea frequently leads to outbreaks within a brief period and affects numerous individuals [7].

Diarrhea can stem from either infectious or non-infectious factors, with infection being the predominant cause. Bacterial, parasitic, and viral infections are the most prevalent contributors to infectious diarrhea [8, 9]. Diarrhea also may result from malabsorption, inflammatory bowel disease, food poisoning, or the effects of medications [10, 11]. The cause of diarrhea can be categorized into six primary groups: infections (bacterial, viral, or parasitic), malabsorption, allergies, poisoning, immunodeficiency, and various other causes [12].

Management of diarrhea, according to the World Gastroenterology Organization (WGO) in 2012, includes oral rehydration therapy, zinc supplements, diet, probiotics, and antibiotics [13]. Antibiotics are the most widely used drugs for infections caused by bacteria. Approximately 40-62% of studies suggest that using antibiotics is not warranted for conditions that do not genuinely require them. The appropriateness of antibiotic usage in different hospitals was discovered to range from 30% to 80%, not aligning with indications. High intensity of antibiotic use leads to bacterial resistance to antibiotics, which has an impact on morbidity and mortality [14]. Extended antibiotic usage can lead to diarrhea in vulnerable individuals, i.e., the elderly [15]. Over the past two decades, probiotics have been used to prevent and control gastrointestinal diseases, especially diarrhea, due to prolonged antibiotic use [16].

Probiotics are vital microorganisms that support the intestinal flora and reduce bacterial colonization of the intestinal wall [16]. Adequate amounts of probiotics yield positive effects on the host's health. Probiotics work by altering the composition and metabolism of the intestinal microbiota, regulating the secretion and absorption of solutes, and enhancing both intestinal barrier function and immune response in the intestines [17]. Probiotics used to prevent or treat diarrhea include *Lactobacillus acidophilus*, *Enterococcus faecium* SF68, *Lactobacillus rhamnosus* GG, and *Saccharomyces boulardii* [16, 18].

Numerous research studies have demonstrated the capacity of specific probiotics to uphold the well-being of older individuals. Prior investigations have indicated the effectiveness of probiotics in preventing and treating diarrhea [10]. Several studies involving elderly individuals indicate that, beyond lessening symptom severity, the consumption of probiotics also influences the frequency and/or duration of antibiotic-related diarrhea or antibiotic-associated diarrhea (AAD). Additionally, probiotics have been employed in conjunction with antibiotics as a therapeutic approach for *Clostridium difficile* [19]. Contrary findings from additional studies indicate that probiotics did not exhibit superior efficacy compared to a placebo in diminishing the occurrence of diarrhea-associated *Clostridium difficile* among elderly patients in a hospital setting [20]. Other studies have also shown that supplemental probiotics are associated with a reduced risk of diarrhea in adults but not in elderly diarrhea caused by antibiotics [21].

Based on these reviews, researchers are interested in conducting research in the form of systematic reviews with meta-analysis related to the effectiveness of using probiotics on the incidence of diarrhea in the elderly. The results of this study are expected to provide synthesis related to the use of probiotics for the prevention of diarrhea in the elderly.

2. Materials and Methods

2.1. The Search Strategy

This literature search was designed according to the Preferred Reporting Item for Systematic Review and Meta-Analysis (PRISMA) sorting flow using the PubMed, Science Direct, and Google Scholar search engines. The search flow is provided in Figure 1. Records were obtained by entering keyword combinations on search engines, and the period spanned from 2017 to 2022.

2.2. The Inclusion Criteria

The study consists of records published on international journal sites from 2017 to 2022. All records included in the analysis were original research focusing on the effectiveness of probiotic use in reducing the occurrence of diarrhea in the elderly. These records provided quantitative data and involved respondents aged 55 years and above who received probiotics.

2.3. Data Extraction and Bias Risk Assessment

Extracting information from the records involves capturing various details, including the research title, authors, publication year, location, study type, number of research subjects, types of probiotics used, and quantitative data such as odds ratio and confidence

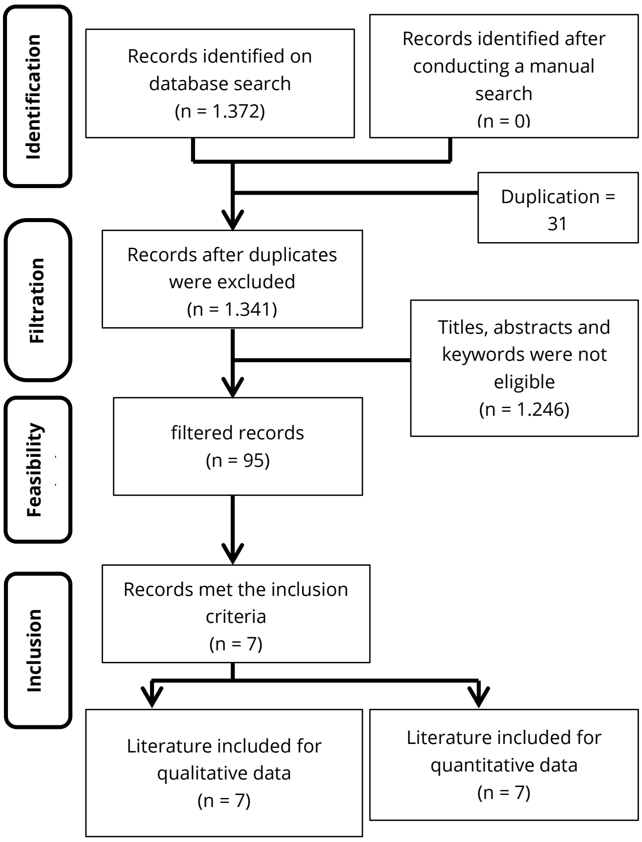

Figure 1. Literature search and sorting flow according to PRISMA flowchart.

interval data. The evaluation of bias risk involves the utilization of two instruments. The first tool employed was the Newcastle Ottawa Scale (NOS), which assessed bias risk in non-randomized studies. The second instrument utilized was the Risk of Bias version 2 (ROB-2), employed to assess bias risk in randomized trials.

2.4. Analysis Methods

The analysis of the data extraction form involves two methods: quantitative and qualitative analysis. Review Manager software version 5 (RevMan 5) was employed to analyze the quantitative data forms. This was developed by the Cochrane Collaboration, an international organization focused on evidence-based medicine. RevMan 5 is available for download from the Cochrane website.

3. Results

3.1. Study Characteristics

The systematic search identified a total of 1372 articles. Following the application of the predefined inclusion criteria, seven articles were deemed eligible for further analysis (Figure 1). Fundamental features of the records encompass details regarding the size of respondents and their age, dosage of probiotics, and the outcomes of the NOS assessment, which are provided in Tables 1 and 2.

Seven records included in this study were published in the period between 2017 and 2022. The records are randomized control trial studies, case-controlled trials, pragmatic participatory evaluation, retrospective cohort, and retrospective observational. These studies were conducted in several countries, namely Japan, the United Kingdom, the Netherlands, Canada, and the United States. The final point in this analysis is the odds ratio, which is calculated by taking the number of respondents who were given probiotics and placebo.

3.2. Bias Risk Assessment

The assessment is conducted using ROB-2 and the NOS. The ROB-2 is the standard tool used to assess the risk of bias in randomized controlled trials (RCTs) included in systematic reviews. It encompasses several domains of bias, such as the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. The result of the assessment using this tool is provided in Figures 2 and 3. Figure 2 shows that most of the domains assessed using the ROB-2 tool are classified as having a low risk of bias (green), which is generally a positive indication of the quality of the included studies. However, the domain "Selection of the reported result" has a slightly different distribution, with approximately 75% of studies classified as low risk (green) and the remaining 25% classified as some concerns (yellow). This concern comes from a record written by Barker, 2017 which is shown in Figure 3.

The results of the quality assessment using the NOS in a non-randomized study showed that out of 4 records, one record was categorized into a score of 7 (25). The other three records have a score of 6 (20-22). Of the three records that have a score of 6, there is one record that is categorized as low quality because there are only two stars in the selection group. It can be concluded that overall, the literature assessed has a low risk of bias or good study quality.

3.3. Forest Plot Analysis

The result of this study is shown in the forest plot provided in Figure 4. The Forest plot provides a visual summary of the data, showing the point estimates and confidence intervals for each study, as well as the overall combined estimate. The variation between studies was heterogeneous with a value of p = 0.003 ($p < 0.05$) in the heterogeneity test, so a random effects model was used for the analysis of 7 records. The forest plot showed a significant relationship between probiotic administration and the incidence of antibiotic-related diarrhea in the elderly with p = 0.04 (p-value ≤ 0.05) and pooled odds ratio value of 0.53 (95% CI 0.29-0.98), so it can be

Table 1. Sample characteristics of probiotic use compared to placebo that fit into the inclusion criteria of the meta-analysis.

Author	The Mean of the Respondents' Age		Number of Probiotic Groups	Number of Control Groups	Diarrhea	
	Probiotic	Control			Probiotic Group	Control Group
Barker et al. [22]	65.0	57.0	16	15	15	13
Mallina et al. [23]	84	86	105	133	5	7
Alberda et al. [24]	59.9	57.5	16	16	2	5
Shimizu et al. [25]	64.0	64.5	57	122	2	19
Velasco et al. [26]	75.08	76.5	247	67	50	14
Rajkumar et al. [27]	73.7	73.5	549	577	106	103
Wietmarschen et al. [28]	85	83	84	83	17	30

Table 2. Probiotic type and dose.

Authors	Type	Time of Using Probiotics after Antibiotic Usage	Duration of Administration of Probiotics	Control
Barker et al. [22]	*L. acidophilus* NCFM ATCC 700396, *L. paracasei* Lpc-37 ATCC SD5275, *B. lactis* Bi-07 ATCC SC5220, and *B. lactis* Bl-04 ATCC SD5219 (Each consist of 1.70 × 10^{10} cfu per capsule)	Within 48 hours	28 days	Placebo
Mallina et al. [23]	ACTIMEL 97 mL contain *L. casei* (1,0 × 10^8 cfu/mL), *L. bulgaricus* (1,0 × 10^7 cfu/mL), and *S. thermophiles* (1,0 × 10^8 cfu/mL)	Within 48 hours	Duration of antibiotics + 3 days	Placebo
Alberda et al. [24]	*L. casei* (2 × 10^{10} cfu /day) *Paracasei* CNCM 1-1518 (DN-114001) 10^{10} cfu	Within 48 hours	Duration of antibiotics + 30 days	None
Shimizu et al. [25]	*Yakult BL Seichoyaku* (*Bifidobacterium breve* 1,0 × 10^8, and *L. casei* 1,0 × 10^8), dan *Galactooligosaccharides* (10g/day)	Within 3 days	28 days	None
Velasco et al. [26]	*L. acidophilus* La-5 (5 × 10^6 cfu/mL), *L. casei* Lc-01 (1 × 10^7 cfu/mL), *B. lactis* Bb-12 (1 × 10^8 cfu/mL), *S. thermophiles* STY-31 (2 × 10^9 cfu/mL), and *L. bulgaricus* LBY-27 (5 × 10^6 cfu/mL)	Within 48 hours	Duration of antibiotics + 5 days Followed up for one month	Placebo and none
Rajkumar et al. [27]	*L. casei* DN114001 (10^8 cfu/mL), *L. delbrueckii subspecies bulgaricus* and *S. thermophiles* (10^6 cfu/mL)	Within seven days	Duration of antibiotics + 2 weeks	Placebo
Wietmarschen et al. [28]	*Bifidobacterium bifidum* W23, *B. longum* W51, *Enterococcus faecium* W54, *L. acidophilus* W37 dan W55, *L. paracasei* W20, *L. plantarum* W62, *L. rhamnosus* W71, and *L. salivarius* W24 (Each 10^{10} cfu)	At the beginning of antibiotic administration	Duration of antibiotics + 1 week	None

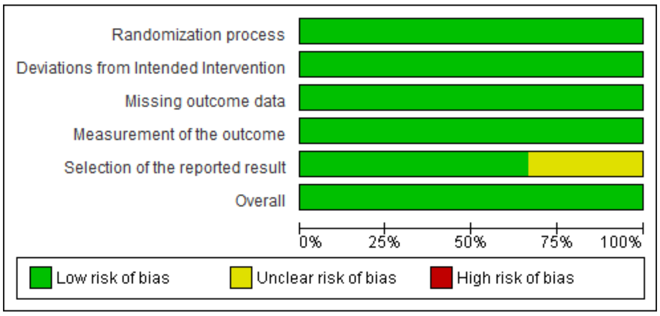

Figure 2. 1tool.

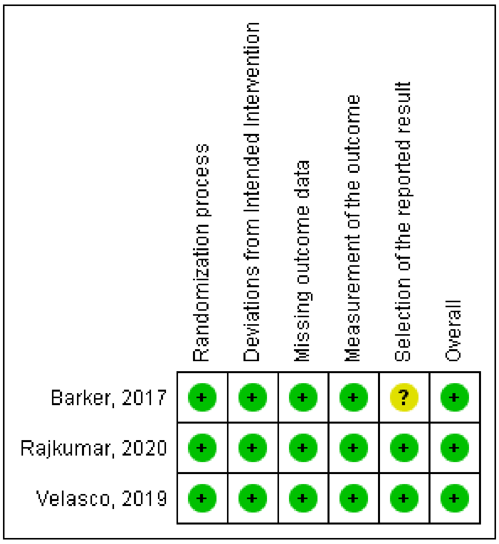

Figure 3. Inference of risk bias using the ROB-2 tool.

concluded that probiotic administration in the elderly can prevent antibiotic-related diarrhea 0.53 times compared to placebo.

3.4. Publication Bias

Publication bias is identified by using a funnel plot and looking at whether the funnel plot shows symmetrical or asymmetrical shapes. The results of the funnel plot are shown in Figure 5. The funnel plot in this study shows that the plot results on the right and left sides are not symmetrical with each other, so they do not form a reverse funnel, which indicates that there is a publication bias that magnifies the effect of real probiotics (over estimate*)*.

3.5. Sensitivity Test

Sensitivity analysis aims to assess whether the results of the meta-analysis are relatively stable to changes or not. Sensitivity analyses involve comparing fixed-effect models to random-effect models. The fixed effect model is used when data variants are homogeneous (p-value≥ 0.05), while the random effect model is used when data variants are heterogeneous (*p*-value <0.05). The conducted sensitivity tests are significantly restricted due to the exceedingly small number of studies. The contrast between the outcomes of the fixed-effect model and the random-effect model is presented in Table 3.

There is a difference in pooled odds ratio (OR) and confidence interval (CI) values observed in the fixed-effect model and random-effect model. There is a decrease in the pooled OR value from 0.82 to 0.53, thus slightly widening the confidence interval.

4. Discussion

4.1. The Effectiveness of Probiotic Use on the Incidence of Diarrhea

This systematic review indicates that probiotics effective in reducing antibiotic-related diarrhea originate from four distinct genera: *Lactobacillus, Bifidobacterium, Streptococcus,* and *Enterococcus*. Johnston et al. supported this finding in their systematic review, which comprised 20 randomized controlled trials involving 3,818 patients. Their study aimed to assess the effectiveness of probiotics in preventing *Clostridium difficile*-associated diarrhea (CDAD). Johnston et al. identified indications supporting the notion that the use of probiotics led to a reduced risk of diarrhea, with a relative risk (RR) of 0.34 (95% CI 0.24 to 0.49; I^2 = 0%). Moreover, no clinically significant increase in side effects was observed. The probiotics employed in their study included *Bifidobacterium, Lactobacillus, Saccharomyces*, and *Streptococcus* [29]. Yet, the diversity within the ultimate population in the collective analysis, as well as the variety of probiotics utilized and the ambiguity surrounding the duration of probiotic use, stand as significant constraints of the Johnston et al. study.

The study by Wietmarschen et al. showed multispecies administration of probiotics (*Bifidobacterium, Enterococcus*, and *Lactobacillus)* significantly reduced the risk of antibiotic-associated diarrhea and no serious side effects [28]. The same results were also shown by Barker et al. and Shimizu et al., who stated that the use of probiotics can significantly decrease the frequency and duration of diarrhea compared to placebo. However, Barker *et al.* There was no significant difference in Clostridium difficile-associated diarrhea recurrence rates or functional improvement over time between treatment groups [22, 25].

This systematic review has shown that *Lactobacillus* is a good species for the prevention of antibiotic-related diarrhea, one of which is *Lactobacillus casei*. This was shown in the study of Alberda et al., which stated that participants who participated in the trial amounted to 32 people who consistently received two doses per day of

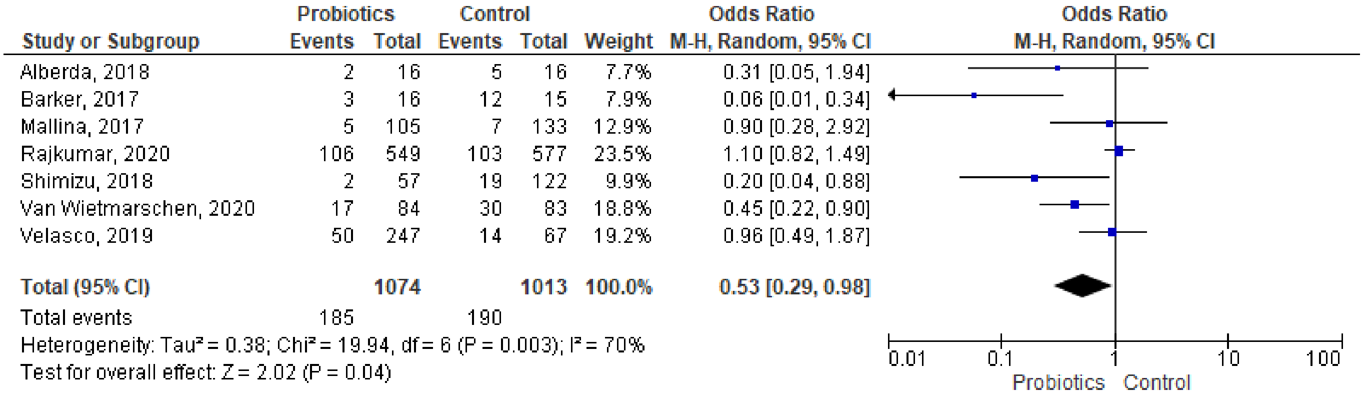

Figure 4. Forest Plot of the effectiveness of probiotic use on the incidence of diarrhea in the elderly.

Table 3. Comparison of Pooled Odds Ratio estimate between Fixed Effect Model and Random Effect Model

Research Variables	*P* value Heterogeneity	Fixed Effect Model	Random Effect Model
The effectiveness of the use of probiotics	P = 0.003	OR 0.82 (0.65, 1.03)	OR 0.53 (0.29, 0.98)

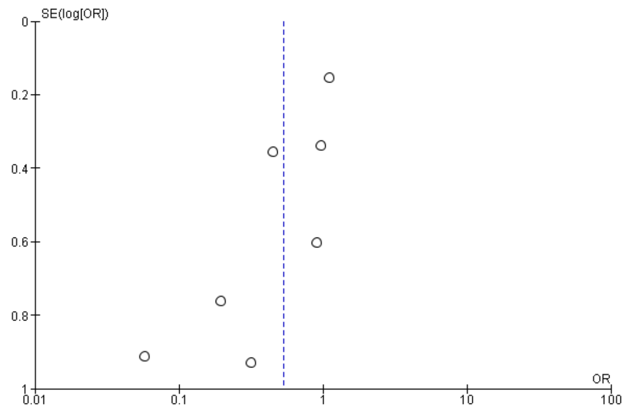

Figure 5. Funnel Plot of the effectiveness of using probiotics on the incidence of diarrhea in the elderly.

probiotics that provide 20 billion *Lactobacillus casei* organisms per day. Antibiotic-associated diarrhea was documented in 12.5% of the *Lactobacillus casei* probiotic group and 31.3% in the control group [24].

Antibiotic-induced diarrhea is most common in the elderly due to extensive antibiotic use. Antibiotics are usually used for the treatment of various infectious diseases. Unfortunately, its use can lead to potential clinical complications, such as the emergence of microorganisms resistant to antibiotics. Older patients have a greater risk of antibiotic-related diarrhea because the incidence and prevalence of acute and chronic diseases, drug consumption, and polypharmacy all increase with age. In addition, age may be associated with changes in gut microbiota that make elderly patients more susceptible to the effects of antibiotics [30].

The mechanism of antibiotic-related diarrhea remains unclear. However, according to Zhang et al. Antibiotics destroy diversity and decrease the amount of intestinal flora. Therefore, pathogenic bacteria colonize and grow inside the intestine. Undigested carbohydrate molecules accumulate in the intestines, causing diarrhea. The role of probiotics in preventing the development of antibiotic-associated diarrhea is by altering the pH of the intestine, which is not suitable for the reproduction of pathogens, inhibiting bacterial toxin secretion, probiotics effectively competing for nutrients and binding sites with pathogenic bacteria, and protecting the immune system (*barrier*) and intestinal mucosa [15].

The results of this systematic review are in line with an earlier systematic review, a study conducted by Zhang et al., consisting of 8 RCTs recommending the elderly can routinely use probiotics to prevent the development of diarrhea while receiving antibiotic treatment [15]. The same results were also shown by Blaabjerg et al., in their systematic review of 17 studies with a total of 3,631 samples found that the use of probiotics can reduce the risk of antibiotic-related diarrhea by 51% (RR 0.49; 95% CI 0.36 to 0.66; I^2 = 58%) with moderate evidence quality according to *Grading of Recommendations, Assessment, Development and Evaluations* (GRADE) [31]. Study by Videlock et al., 34 studies and 4,138 patients also showed a risk-reducing effect of diarrhea from probiotics, with an RR of 0.53 (95% CI 0.44-0.63) [32].

Researchers found three kinds of literature, namely Mallina et al., Rajkumar et al., and Velasco et al., state that probiotics are not effective in lowering the risk of antibiotic-related diarrhea. This was found because the results of ineffective probiotics were related to the limitations of the trial. For example, probiotics that are not following the doctor's recommended dose. There are some patients who not only get probiotics but also get high doses of antibiotics, so the probiotics given at that time have no effect anymore.

4.2. Types and Dosages of Probiotics

Probiotics are live microorganisms that are thought to improve the balance of host microbes, prevent potential disruptions to the intestinal flora associated with antibiotic use, reduce the risk of colonization by pathogenic bacteria in the intestinal wall, increase the production of antimicrobial substances, and change in the acidity of the intestinal environment to minimize the possibility of infection by producing fatty acids [33]. Current evidence remains unclear whether probiotics can reduce the incidence of antibiotic-related diarrhea. WHO also has not recommended the dosage and duration of probiotic supplementation for diarrhea.

Qualitative data analysis in this study aims to determine the type and dose of probiotics used in preventing diarrhea in the elderly. Based on systematic reviews, dosages and types of probiotics vary between published studies. For example, the study conducted by Wietmarschen et al. using multiple probiotic strains, namely *Bifidobacterium bifidum, Bifidobacterium longum, Enterococcus faecium, Lactobacillus acidophilus, Lactobacillus paracasei, Lactobacillus plantarum, Lactobacillus rhamnosus, and Lactobacillus salivarius* (each at a dose of 10^{10} cfu) provided a better preventive response than placebo in the elderly [28]. Studies conducted by Alberda et al. using a single probiotic strain, Lactobacillus casei (2×10^{10} cfu per day), provide a viable alternative for the prevention of antibiotic-related diarrhea in the elderly [24].

Studies conducted by Barker et al. using multiple probiotic strains, namely *Lactobacillus acidophilus, Lactobacillus paracasei,* and *Bifidobacterium lactis* (each at a dose of 1.70×10^{10} cfu per capsule) provided a better preventive response than placebo in the elderly [22]. A study conducted by Shimizu et al. using multiple probiotic strains, *namely Yakult BL Seichoyaku* (*Bifidobacterium breve* 1.0×10^8, *and L. casei* 1.0×10^8) and *galactooligosaccharides* (10g/day) significantly reduced the incidence of diarrhea compared to placebo use [25].

Studies conducted by Velasco et al. using multiple probiotic strains, namely *L. acidophilus* (5×10^6 cfu/mL), *L. casei* (1×10^7 cfu/mL), *B. lactis* (1×10^8 *cfu/mL), S. thermophiles* (2×10^9 *cfu/mL),* and *L. bulgaricus* (5×10^6 *cfu/mL)* showed no significant effect between the use of probiotics versus placebo in the elderly. There was no difference in the duration of diarrhea, the maximum number of bowel movements, or the length of hospitalization due to diarrhea between groups. All causes of death did not differ between groups [26]. The same results were shown in a study conducted by Rajkumar et al. using multiple probiotic strains, namely *L. casei* (10^8 cfu/mL), *L. delbrueckii* subspecies *bulgaricus* (10^6 cfu/mL), and *S. thermophiles* (10^6 cfu/mL), showed no significant effect between the use of probiotics compared to placebo in the elderly [27]. The same results were also shown in a study conducted by Mallina et al. using twice-daily probiotic ACTIMEL 100 grams (97 mL) containing L. casei (1.0×10^8 cfu/mL), *L. bulgaricus* (1.0×10^7 cfu/mL), and *S. thermophiles* (1.0 $\times$ 10^8 *cfu*/mL) showed no significant reduction in diarrheal incidence in patients receiving probiotics [23].

Certain members of the *Lactobacillus* genus generate acid, reducing intestinal pH, releasing exotoxins, hindering the proliferation of pathogenic bacteria, and impeding the escalation of enterotoxin to the epithelium. Probiotics, specifically species like Lactobacillus and Saccharomyces, also bolster the innate and adaptive immune systems through diverse mechanisms [34]. As per Zhang et al., the effectiveness of probiotics in preventing diarrhea is intricately linked to the initiation time of probiotic treatment, with their efficacy potentially diminishing when administered later to elderly patients. Prolonged probiotic treatment duration leads to more effective prevention of diarrhea [15].

A multitude of probiotic species has been subject to examination, with systematic reviews highlighting the prevalent administration of genera such as Lactobacillus, Bifidobacterium, and Streptococcus. This observation is in line with earlier meta-analytical research carried out by Blaabjerg et al. [31]. The duration of probiotic intake in this study exhibited variability, spanning from a minimum of 3 days to a maximum of 4 weeks. The dose of probiotics given also varies and ranges from a minimum of 1.0×10^6 cfu to a maximum dose of 2×10^{10} cfu.

The result of this study shows the significant role of probiotics in decreasing diarrhea in the elderly. However, the findings in this study may be skewed by publication bias, as only published studies were included. This could inflate the perceived effectiveness of probiotics, as studies with negative results may have been excluded. Moreover, a limited number of databases were used, which may have restricted the scope of potentially relevant studies. Additionally, the quality of the included studies varies, which could impact the reliability of the meta-analysis results. Studies with lower methodological quality may introduce bias, undermining the validity of the findings. Lastly, the generalizability of the findings may be limited, as the included studies may have focused on specific demographics or health conditions in the elderly population, limiting their applicability to a broader population of elderly individuals.

The finding that probiotics can effectively reduce the risk of antibiotic-related diarrhea in the elderly could be a valuable intervention in clinical practice. This finding has significant public health implications, given the widespread use of antibiotics in this population. Probiotics may help lessen the burden of antibiotic-related diarrhea and enhance the overall health of elderly individuals. Further research is needed to determine the best type, dosage, and duration of probiotic therapy for this purpose. Future studies could also investigate the mechanisms of probiotics' action and their long-term effects on gut health and overall health outcomes in the elderly.

5. Conclusions

In conclusion, our systematic review and meta-analysis examining the effectiveness of probiotics in reducing the incidence of diarrhea in the elderly have yielded significant results. The use of probiotics was found to significantly reduce the risk of antibiotic-related diarrhea in this population. The most commonly used probiotics were *Lactobacillus*, *Bifidobacterium*, and *Streptococcus*, with varying durations of consumption (ranging from 3 days to a maximum of 4 weeks) and doses (ranging from 1.0×10^6 CFU to 2×10^{10} CFU). These findings support the effectiveness of probiotics as a potential intervention for reducing antibiotic-related diarrhea in the elderly. Further research is warranted to optimize the type, dose, and duration of probiotic therapy for this purpose.

Author Contributions: Conceptualization, D.M. and N.A.P.; methodology, D.M.; software, D.M; validation, V.D.M., N.A.P. and S.W.; formal analysis, D.M.; investigation, H.N.S; resources, H.N.S.; data curation, D.M.; writing—original draft preparation, D.M.; writing—review and editing, S.W.; visualization, V.D.M.; supervision, N.A.P; project administration, S.W.; funding acquisition, V.D.M. All authors have read and agreed to the published version of the manuscript.

Funding: This study does not receive external funding.

Ethical Clearance: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data utilized in this study is globally accessible and freely available on the internet.

Conflicts of Interest: “All the authors declare no conflicts of interest.

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