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Phytobezoar Predisposing Factors: Re-evaluating the Role of Dietary Fibres - A Systematic Review

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Abstract
Background: Phytobezoar is defined as the compaction of indigestible food material (mainly fibrous plant tissues) localised in the gastrointestinal tract (GIT), leading mainly to GI obstruction (GIO) and many GI health problems. Some researchers claimed that vegetables, fruits, and other DF-containing foods are the main culprits in phytobezoar formation.
Objective: systematic review of the available case reports and case series to identify the actual culprits of phytobezoar formation and to distinguish the role of dietary fibres.
Data Source: We searched PubMed, MEDLINE, Web of Science platform, and Google Scholar with no restriction through April 2026.
Study Selection: available phytobezoar cases (including reports, series and reviews).
Data Extraction: We extracted data on patient demographic information, diagnosis, and emphasizing the predisposing/risk factors.
Data Synthesis: 218 publications met inclusion criteria, reporting on 1382 cases. The cases have been categorized according to the predisposing/ risk factors.
Limitations: no limitation for time, age, and geography, however the study is limited to English publications.
Conclusion: the study unambiguously distinguished the actual predisposing/risk factors for phytobezoar formation including previous GI surgeries, unusual foodstuffs, among others. Although phytobezoars are usually formed of undigested fibrous plant material, however, proper consumption of the recommended amounts of dietary fibre-containing foods is not responsible for phytobezoar formation.

Keywords: Dietary fibres, phytobezoar, bezoar culprits, gastrointestinal surgery.

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1. Introduction

The term "Phytobezoar" has been derived from the Greek word "phyton" (plant) and "bezoar" is thought to refer to the Persian words *pâd* (expelling) and *zahr* (poison).[1,2] The medical term "bezoar" was established in the medical literature since 1854 by Dr. Richard Quain.[3] In medical terminology, bezoars represent an agglomerate of foreign materials, hairs (trichobezoars), indigestible plant material (phytobezoars), or drugs (pharmacobezoars) that ingested, accumulate and solidify inside GIT, creating a solid phase that progressively grows until the point it can prevent the normal digestive process and often obstructs GIT.[3-6]

Although rare cause of primary gastrointestinal obstruction, phytobezoars are the most common cause of bezoar occurrence, accounting for up to 70% of all bezoars.[4,7,8]

Bezoars are responsible for 0.4% - 4% of cases of mechanical gastrointestinal obstruction worldwide. [9,10] Some researchers have claimed that vegetables, fruits, and other fibre-containing foods are the main culprits in the formation of phytobezoars.[3,5,6,11,12] However, they do not differentiate between the recommended amount of dietary fibres and other fibrous plant tissues (unusual food material) that are consumed intentionally or accidentally, leading to phytobezoar formation. Dietary fibres (DF) is a term used to describe indigestible, soluble and insoluble part of usual foodstuffs, especially carbohydrates.[13] These DF are found naturally at a reasonable level in our healthy foods e.g. popular fruits and vegetables, either as soluble fibres (e.g. mucilaginous materials: psyllium seed, chia seeds, Okra, fenugreek, salep tubers, grains …etc.) or insoluble fibres (e.g. grain walls (wheat Bran, oat bran), Beans, shelled nuts, vegetables, fruits ...etc.).[14-17] Here, we have to recognise non-food plant fibres e.g. plant wood fibers, hard or leathery seed skins (sunflower seed coats, watermelon seed coat, Apricot pits, etc.,), these types of plant fibres are not considered as DF. According to common recommendations, DF should be consumed regularly as food habit at a daily dose of 30-38 g for adult men as a part of 2600 kcal food/day, and 28-30 g for adult women as part of 2000 kcal daily food.[13-16] Dieticians and healthcare providers must consider these values in their prescriptions and recommendations to the public. They must also recalculate these quantities based on patient's age and health status. Consumption of the recommended amount of DF has a positive impact and offers great health benefits. DF consumption was linked to increased insulin sensitivity,[18] improved blood sugar levels,[18] management of diabetes,[19]improvement of obesity and body mass index (BMI),[18] prevention of constipation[20], lower blood cholesterol levels,[21] decreased fat and carbohydrate absorption,[22]and lowering of blood pressure.[23,24] Other benefits have also been confirmed, such as improvement of GIT movement ,[22] and increased mineral absorption in the intestinal tract,[25] reduces energy intake,[26] decreases the chance of pathogenic microbial growth, increases the chance of growth and development of beneficial microbial flora,[27] biosynthesis of short-chain fatty acids with valuable health benefits,[28] improvement of the immune system,[29] decreases the absorption of toxic substances and carcinogens for GIT,[30] and prevention of tumour formation (e.g. colorectal cancer) and consequently, enhances the quality of life.[13,31,32]

1.1 Mechanisms of phytobezoar formation:

Phytobezoars are formed in the alimentary canal as a result of specific indigestible plant tissues and biological reactions that interact to form solid or semisolid concretions or conglomerates that are difficult to hydrolyze or fragment and cause partial or complete GIO. Two scenarios have been accepted as mechanisms for phytobezoar formation.

- **Chemical scenario:** Phytobezoar formation (diospyrobezoars) due to consumption of persimmon fruits (*Diospyros kaki*) has been confirmed. Unripe persimmon fruits contain high concentrations of tannins (phlobatannin: shibuol), fibre contents, and indigestible soluble carbohydrates.[33,34] When tannin comes into contact with gastric juice (higher gastric acidity) in the stomach, especially in an empty stomach, it can precipitate and undergo polymerization, forming a coagulum that includes cellulose, hemicellulose, and protein. This coagulum serves as the foundation for the bezoar. As this cluster continues to evolve, it undergoes dehydration and solidification processes. This solidified mass grows, resists fragmentation or hydrolysis and can then be moved to narrow spaces in the GIT, leading to obstruction.[7,8,34]
- **Mechanical scenario:** the formation of phytobezoar may be due to accumulation of indigestible plant materials such as hard leathery or woody plant material (e.g. unshelled watermelon seeds, unshelled pumpkin seeds), or a high amount of hygroscopic material (e.g. dry chia seeds), where these materials accumulate and grow to form a nucleus of phytobezoar under the influence of predisposing factors such as GIT strictures or GI laziness.[35] However, other scenarios have not been confirmed for phytobezoar formation due to easily digestible food materials such as rice, potato-based foods, and meat boluses.[36]

1.2 Phytobezoar - related complications and health problems:

Gastrointestinal obstruction (GIO) is the main complication of phytobezoar formation, where the

phytobezoar can be localised in the stomach and move to close the pyloric canal or continue moving to cause small bowel obstruction in the duodenum, jejunum, or ileum, preventing the normal function of the GIT.[3] However, seed shell-related phytobezoars are commonly formed or agglomerated in the large intestine.[37-39] Gastrointestinal (GI) obstruction of the GIT can lead to serious health issues, such as GI perforation, GI bleeding, intussusception, and strangulation, which may lead to local ischaemia and necrosis.[6,40] Indeed, acute pancreatitis[41], Jejunal Obstruction[42], GI Hemorrhage[43], Restrictive lung pattern[44], small bowel perforation[45], Proximal Ileal Perforation[46], body weight loss, GI ulceration, GI inflammation, fistula formation, and adhesion have also been reported as complications for phytobezoars.[47]

phytobezoar cases have been reported in almost all geographic regions, worldwide due to fibrous and less likely non-fibrous plant materials and non-plant foodstuffs. The exact role of dietary fibres in the formation of phytobezoar is debatable. Consequently, an urgent literature review is needed to clarify the actual causes of phytobezoars. The present study was designed to investigate the published phytobezoar cases from global healthcare centres in order to explain the actual culprits of phytobezoar formation, and distinguishes the role of dietary fibres.

2. Materials and Methods

2.1 The study selection and literature search strategy

The data of the present systematic review were obtained from Life-science databases (PubMed, MEDLINE, Web of Science platform, and Google Scholar).48-51 The search was conducted independently by two reviewers (MA and AA) using specific terms "phytobezoar", "phytobezoar-predisposing factors", "phytobezoar-dietary fibres", and "dietary fibres" to identify studies relevant to phytobezoar cases and the role of dietary fibres. The obtained search results were filtered first by screening titles and abstracts then further filtering has been made to exclude duplicate and irrelevant publications. Then further filtering was performed to exclude irrelevant publications and those lacking important information. Disagreements were resolved by consensus. The search included studies published up to 2026.

2.2 Quality assessment of the eligible publications

The assessment was carried out independently by two investigators (MA & AA) addressing the items available in the case reports. These items include 1) relevance of the title to the reported information, 2) adequacy of demographic information, 3) relevant past history, 4) case diagnosis, 5) type of concretion (phytobezoar mass), and 6) pre-disposing/risk factors if any, 7) discussion of the relevant evidences. Possible item ratings are yes, partially, or no; disagreement was resolved by consensus.

2.3 Inclusion and Exclusion criteria

Inclusion criteria: All studies reported human cases of phytobezoar. There was no limitation for time of publication, and no limitation of countries or geographic regions.

Exclusion criteria: 1) non-plant-related bezoar cases (e.g. trichobezoars, pharmacobezoars); 2) all articles that are free from reported phytobezoar information; 3) non-human phytobezoar cases (e.g. animal bezoar cases); 4) repetitions or case duplicates were also excluded; 5) lacking of important information. 6) articles published in languages other than English.

2.4 Data synthesis and analysis

218 articles have been selected based on the eligibility criteria for inclusion and exclusion, Descriptive statistical analyses were used to data syntheses and categorization process. Microsoft Excel software (Microsoft, USA) has been utilized for Statistical analysis, classification, designing graphs and extracting tables.

3. Results

3.1 Quality appraisal

Based on the items of quality assessment, the overall quality of the included studies was moderate to high. The titles were relevant to the reported information (100%), adequacy of demographic information (age, gender, nationality, residency) (80.4%), relevant past history (93%), case diagnosis (99.0%), type of concretion (phytobezoar mass) (67.9%), pre-disposing/risk factors if any (89.9%), and discussion of the relevant evidences (98.8%).

3.2 Publication characteristics

The eligible publications (218 articles), have been investigated (Figure 1). These eligible publications were found to comprise almost all relevant topics, almost all geographic regions (worldwide), with no limited time period through 2026. The selected articles included case reports, case series, case reports with reviews, review of cases, and other relevant reviews of phytobezoar occurrence. The eligible records were carefully reviewed, and extracted to the Microsoft excel sheets, then categorized into groups as seen in the provided tables (S1 appendix). Total Number of reviewed phytobezoar cases (1382 cases) have been categorised according to patient age with or without previous GI surgery (Figure 2). The phytobezoar cases without previous GI surgery have been classified according to predisposing/risk factors (Figures 3).

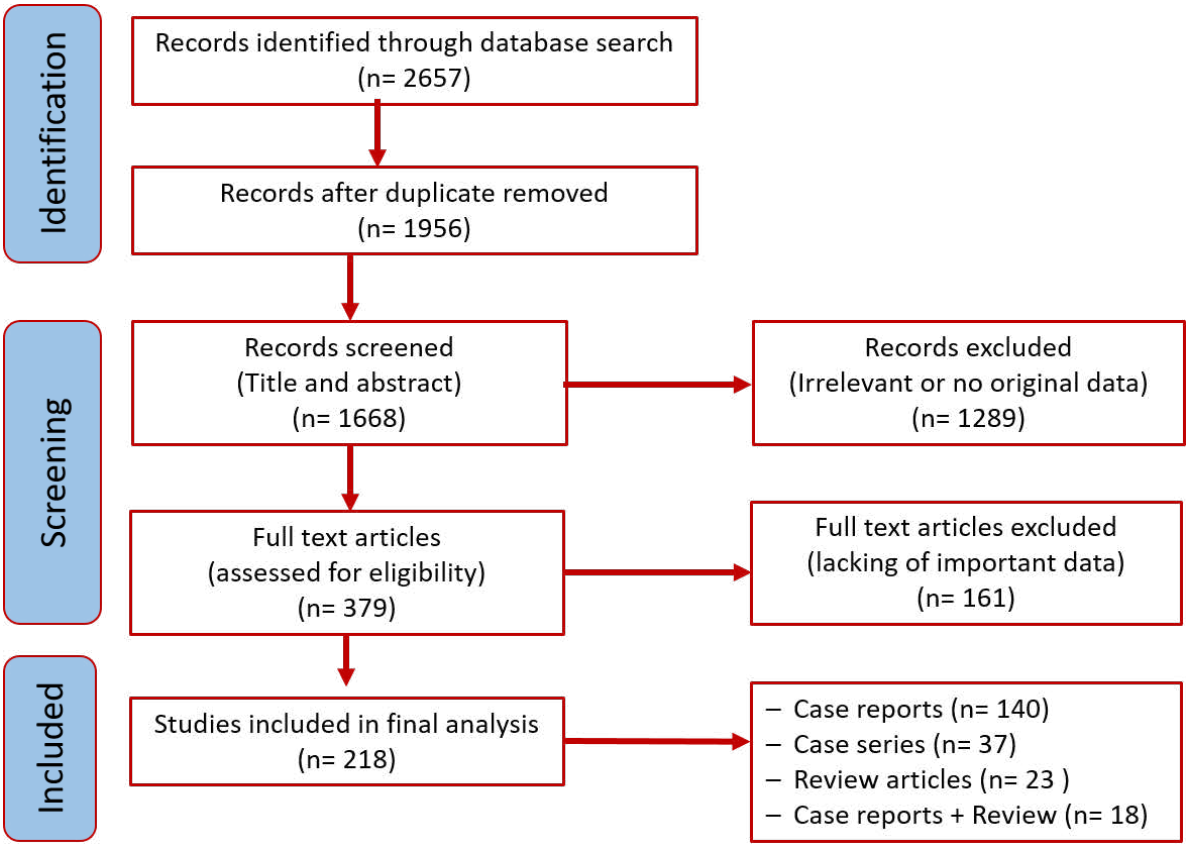

Figure 1. PRISMA 2020 Flow diagram for the selection of records and publications.

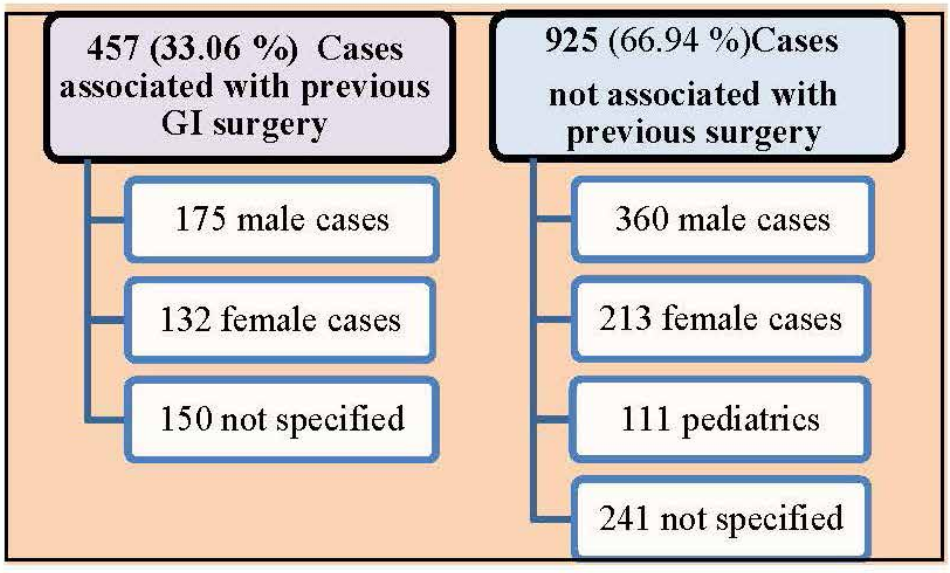

Figure 2. Classification of phytobezoar cases according to age and previous GI surgery.

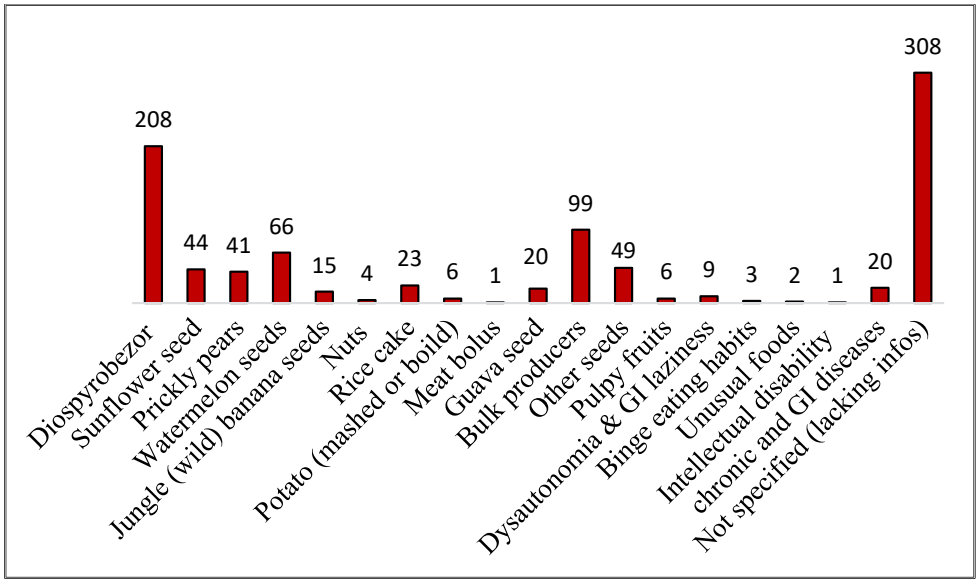

Figure 3. Classification of phytobezoar cases not associated with previous GI surgery.

3.3 Phytobezoar predisposing factors

Several predisposing/risk factors have been recognised (see supporting information tables 1 -6).[34,35] The most common predisposing/risk factors (Figure 4) have been considered the main culprits and discussed in detail in the following sections.

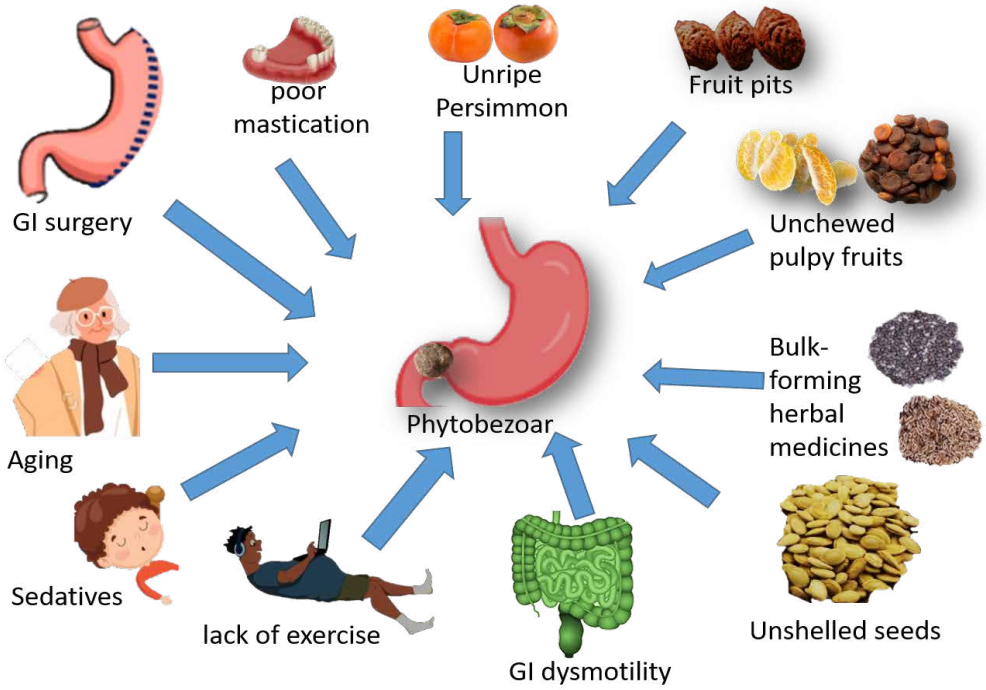

Figure 4: The main culprits for phytobezoar formation

3.4 The Actual culprits in phytobezoar formation

3.4.1 Previous GI surgery

Regardless of the nature of the foodstuff, previous GI surgery represents the major risk factor for phytobezoar formation.[52-59] The present study confirmed the presence of 457 phytobezoar cases (33.06 % of all reviewed cases) of different food materials associated with previous GI surgery (S1 appendix - table 1).

3.4.2 Unripe Persimmon ingestion

In the present study, we have found 296 (diospyrobezoars) cases (21.41 % of total reported cases) due to persimmon ingestion,[8,35,60,61,62] of which 88 cases associated with previous GI surgery while 208 cases not associated with previous surgery, (S1 appendix - table 2). However, Izumi et al. suggested a widely accepted mechanism (chemical scenario, mentioned above) for diospyrobezoar formation based on gastric acidity and the chemical nature of unripe persimmon fruits which contain a large quantity of tannin (shibuol) to form a sticky coagulum easily converted to a semisolid ball representing the basic nucleus of diospyrobezoar.[34] Thus, diospyrobezoar formation depends on two factors: 1) excessive consumption of unripe persimmon fruits, and 2) concentrated gastric acidity. According to Izumi's hypothesis, the fibre content is not responsible for diospyrobezoar formation. Nonetheless, the United States Department of Agriculture (USDA) report[63] states that the total fibre content of persimmon fruit is only 3.6 g/ 100 g fruits, this equal to only 10% of the recommended daily amount of DF.

3.4.3 Unshelled/woody-skin Seeds

44 cases of sunflower seed bezoar, 41 cases of prickly pear bezoar, 66 cases of watermelon seed bezoar, 15 cases of jungle banana seed bezoar, 20 cases of guava seed bezoar, in addition to 49 cases of other seed bezoars including, pumpkin, date, Olive, *Baccaurea macrocarpa*, jaboticaba, sesame, peanuts, lupin, popcorn, pomegranate, tangerine, granadilla, lentil, cherry pits, box myrtle and mango seed bezoars[64-67] have been reported in the present study (S1 appendix - table 3). The unshelled seeds (e.g. sunflower and watermelon seeds) are not usual food; they are ingested with their seed coats (seed skins) which are formed of hard woody or cellulosic shells, and are mainly consumed accidentally or due to psychic disorders.

3.4.4 Fruit kernels (Pits)

Hard pits including date and olive pits[38], apricot pits[68,69], nectarine pit[70], prune pit[71], chestnuts[72,73], all have been reported as causes for phytobezoar formation. (S1 appendix - table 3). These types of phytobezoars are due to high cellulosic woody indigestible plant tissues; however, these plant tissues have never been considered dietary fibres and are accidentally ingested forming bezoar and may develop GIO.

3.4.5 Dietary fibre-containing herbal medicines without professional instructions

FDA, 2007[74] reported a total of 78 cases of phytobezoar or GIO due to ingestion of laxative drugs formed mainly of psyllium seeds or psyllium seed husks in the period from 1980 to-2000 in the USA.[74] Moreover, Hefny et al., Salguero Molpeceres et al., Agha et al., and shin et al.[75-78] have reported cases of gastrointestinal obstruction due to psyllium seeds and psyllium husks. A similar type of GIO has been reported by Rawl and Brawne due to chia seed ingestion.[79] Similar issues have been reported[80-85] due to the ingestion of Karaya gum, linseed, wheat bran, and oat bran (S1 appendix - table 4). These herbal medicines contain a reasonable amount of dietary fibre (soluble and insoluble). Ingestion of such products must follow the orientation and recommendations of the health authorities, considering both the method of ingestion and the quantity to be ingested. These bulk-forming herbal medicines are strong hygroscopic agents due to their soluble fibre content (mucilages). Psyllium and chia seeds can absorb water equal to 28 times their weights. Therefore, the recommended dose of these herbal drugs must be soaked in sufficient quantity of water for at least 2 Hours prior to ingestion and must be swallowed with plenty of water; otherwise, when ingested dry, they will absorb GI fluid and conglomerate to form a sticky and hard compaction, leading to GIO. Similar cases have been reported due to ingestion of dry psyllium seed husk powder[78], bran[82,84].

3.4.6 Poor mastication of Pulpy Fruits and Vegetables

Pulpy fruits and vegetables, such as orange pulp, dry apples, dry apricots, fibrous leaves of rhubarb, and dry grapes[57, 86, 87], have been reported as risk factors for bezoar formation (S1 appendix - table 5). Buchholz and Haisten reported 150 cases of GI obstruction due to different types of phytobezoars (orange pulp, figs, apples, grapefruit, persimmons, coconuts, cabbage, beans, and potatoes) following gastric surgery for duodenal ulcer.[57] They mentioned that 90 % of reported cases were due to orange pulp.[57] They attributed the incidence of phytobezoars to gastric surgery which resulted in loss of normal pyloric function with low gastric acidity, in addition to inadequate chewing of fibrous food, leading to GIO.[57] They published a figure showing approximately intact orange segments as a result of poor mastication. Therefore, inadequate chewing, large amounts of pulpy vegetables and/or fruits, inadequate fluid or water intake and/or previous GI surgery are the main culprits for such bezoar formation.

3.4.7 Easily digested food can also produce GIO in certain condition

Many cases of GIO have been reported due to easily-digested foods like rice cakes, mashed potatoes and meat-bolus[36, 57, 88, 89, 90, 91] (S1 appendix - table 5). These reported cases suggested the predisposing factors as aging, improper cooking, quick feeding, and poor mastication as a result of dental disorders.

3.4.8 Unusual foods

Katsinelos et al. reported a case of phytobezoar resulting from the ingestion of a substantial quantity of honeycomb in young, healthy Greek woman aged 44 years.[92] Similarly, Hsu et al. documented an unusual

case of phytobezoars due to the consumption of large amounts of vegetable-derived fats (S1 appendix - table 5). It is important to note that these health fads are not containing dietary fibres and are not considered typical food materials.[93]

3.4.9 Dysautonomia and GI laziness

Many phytobezoar cases due to dysautonomia, dysmotility and GI laziness have been reported. (S1 appendix - table 6). These predisposing factors present as a results of GI surgery, GI disorders and/or chronic diseases.[5,7,56,59,94-97]

3.4.10 Psychic disorders

Boopathy and Palaniswamy reported a case of giant bezoar due to accidental ingestion of cotton thread along with different objects such as pieces of bone, seeds of various fruits, stapler pins, buttons, and metal wires for a patient with mental disability.[98]

3.4.11 Aging

Geriatric patients and healthy individuals of old age are more susceptible to phytobezoar formation, regardless of the type of food material. They have many predisposing factors, for example: 1- decreased physical fitness; 2- the expected dental issues and related poor mastication; 3- chronic diseases like diabetes, hypertension, psychic depression, malabsorption, impaired metabolism, in addition to drug-related side effects on GIT.[6] several hundreds of phytobezoar cases have been reported for elderly patients. [6,61, 99-102]

However, phytobezoars can develop in patients without common risk or predisposing factors; therefore, they should not be underestimated, especially when GIO is predicted.[56]

3.4.12 The role of dietary fibres in formation ofPhytobezoar

Many studies have implicated dietary fibres as the main reason or risk factor for phytobezoar formation,[6,13,103] while others have reported a strong association between vegetable and fruit ingestion and phytobezoar formation.[103,104] Although phytobezoars are composed mainly of plant fibres (DF and/or non-DF), However, there are many prominent evidences that confirms the non-liability of the recommended amount of dietary fibres to form phytobezoar unless the predisposing factors are present. The most prominent evidence is the positive response of the majority of people worldwide to the recommendations of Global health authorities to eat a reasonable amount of dietary fibres daily without reporting phytobezoar formation, except very rare cases. These rare cases have been reported for patient having one or more predisposing factors (e.g. previous surgery, GI laziness, chronic diseases, poor mastication, …..etc.).

4. Discussion

The present systematic review explained prominently the main culprits that responsible for phytobezoar formation. Although phytobezoar are formed usually of plant fibres (dietary and non-dietary fibres),[5,13,34,56] however, the formation of phytobezoar depends always on the presence of the predisposing factors.[2,4,6,7] Despite of the age, gender, race and geography, phytobezoar formation is expected for any person having the predisposing factors[56]. Prevention of full-beneficial dietary fibres-containing foods is not a proper decision. However, several good practices can be applied to prevent and help manage this health problem. These practices include: a) Health education programs for patients at risk such as those with previous GIT surgery and GIT disorders. Based on various studies, it was established that, maintaining gastrointestinal healthy status through regularisation of meal times and appropriate nutrition, drinking sufficient quantities of water, good mastication, and following health authority recommendations are of great value for preventing bezoar formation. b) parents and relatives of babies and children must be exposed to educational health programs to encourage them to enhance awareness about the predisposing/risk factors. c) herbal medicine practitioners and dieticians must strictly follow and implement the governmental regulations for dispensing herbal medicines and bulk-forming drugs. Indeed, unqualified herbal medicine practitioners must be subjected to an appropriate educational programs. d) the patient and people at risk must be educated about the importance of sport exercise and its positive impact on keeping GI function and prevention of bezoar formation. e) early diagnosis by specialised physicians and effective medical intervention have been considered to avoid or minimise the phytobezoar-related complications.[6, 105, 106,107]

4.1 Limitation of the study

- The present study excluded the publications in languages other than English.
- Some records are lacking some information regarding the exact type of phytobezoar.
- Some case reports didn't report the actual predisposing factors, instead they were more interested in diagnosis and management.

5. Conclusion

Phytobezoars are annoying health problem, responsible for approximately 4.0 % of GIO, in addition to other GI health issues. Based on the present study, the responsibility of the recommended dietary fibres for phytobezoar formation is not established. the recommended amount and types of dietary fibres have great beneficial effects and cannot be excluded from the healthy foods. However, much attention must be paid for people at risk, and those having one or more predisposing factors.

5.1 Data Availability Statement

All data summarized in the text and tables of this review article were obtained from previously published studies with appropriate attributions cited in the text and tables and complete references provided in the reference section.

5.2 Supplementary information

- The summary of the reported cases (S1 Appendix)
- PRISMA 2020 checklist (S2 Appendix)

5.3 Disclosure statement

- The authors declare no conflicts of interest, and no financial supports.

5.4 Author Contributions

- Ashour M: Conceptualisation, research proposal, Data collection, formal analysis, writing-original draft, visualisation; Ashour A: critical discussion, case report review, review-original draft.

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S1. Appendix: list of reviewed phytobezoar cases.

Table 1: List for phytobezoar cases associated with previous surgery.

Gender	Age (years)	previous surgery	Other risk factors & medical history	Ref.
Female	51	laparoscopic cholecystectomy	Diabetes mellitus	[1]
Male	65	duodenal ulcer surgery	anamnesis of recurrent ileus	[2]
Male	NA	laparoscopic sleeve gastrectomy (SG)		[3]
Male	NA	laparoscopic sleeve gastrectomy (SG)		[4]
Male	55	Stapled gastroplasty	Nephrolithiasis	[5]
Male	NA	laparoscopic sleeve gastrectomy (SG)		[6]
Male	NA	laparoscopic sleeve gastrectomy (SG)		[7]
Female	33	She had a laparo- scopic Roux-en-Y gastric bypass (LRYGB) for morbid obesity	Obese, Body Mass index: 36.	[8]
150 cases, gender is not specified	NA	All have had previous gastrectomy for duodenal ulcer.	High fiber foods	[9]
Female	63	RYGB		[10]
13 cases (7 males and 6 females)	Range: 44-79	11 patients had previous ulcer surgery, 8 truncal vagotomy with pyloroplasty and 3 partial gastrectomy	Ingestion of persimmon, grapefruits and dried plumes	[11]
Female	68	subtotal gastrectomy due to gastric cancer	dyslipidemia, supraventricular paroxysmal tachycardia anddepression	[12]
Male	75	surgical resction of the sigmoid colon for diverticulitis	he ingested approximately 60 g Oat bran daily	[13]
Male	48	Laparoscopic adjustable gastric banding (LAGB)		[14]
Female,	50	Laparoscopic sleeve astrectomy (in 2014) Roux-en-Y gastric bypass (RYGB) (in 2017)	Poor mastication	[15]
Male	66	Billroth II hemigastrectomy associated with truncal vagotomy to treat a chronic duodenal ulcer	Diabetes	[16]
Female (pregnant)	33	RYGB		[8]
Female	59	laparoscopic adjustable gastric banding (LAGB) for morbid obesity	Obesity and related issues.	[17]
Female	75	a subtotal gastrectomy and Billroth II gastrojejunostomy were performed.	NA	[18]
Female	63	laparoscopic Roux-en-Y gastric bypass surgery	morbid obese	[19]
18 Males/14 Females (1.42/1).	32 cases, (range 17-78) years; Mean age was 53.73±15.56	(19 of them have previous surgery.) 13 have had another predisposing factors.	Peptic ulcera (n = 4, 11.76%), diabetes mellitus (n = 4, 11.76%), cherrylaurel (Prunus Buricerasus) or persimmon (Diospyrus Lotus) intakes (n = 6, 17.64%), mental retardation-trichotillomania (n = 2, 5.88%), high dose intake of H2 receptor antagonists (n = 1, 2.94%) were also found in patients' history.	[20]

Gender	Age (years)	previous surgery	Other risk factors & medical history	Ref.
Male	47	Yes	Raw stinging nettle	[21]
Female	86	appendectomy		[22]
Female	64	Laparoscopic Roux-en-Y gastric bypass		[23]
Female	51	RYGB		[24]
Male	73	Billroth I partial gastrectomy for gastric cancer.		[25]
Female	58	Laparoscopic adjustable gastric banding		[25]
43 cases (23 males and 20 females)	Range: 18-93	8 cases, (18.6%) Gastrectomy	Diabetes, dental problems, Stomach diseases accounted for 25.5%, 43.6%, 69.7% respectively.	[26]
95 cases of 103 (52 Males and 43 Females)	Mean Age : 60.5 ± 11.3) years	gastric surgery (25.2%),	risk factors were history of gastric surgery (25.2%), diabetes mellitus (21.3%), hypothyroidism (15.5%), trichophagia (5.8%), and anxiety disorders (2.9%), respectively	[27]
Female	55	RYGB		[28]
Female	69	open appendicectomy	Mango seed	[29]
Female	66	Appendectomy	Liver cirrhosis	[30]
Male	59	Subtotal gastrectomy		[30]
Male	70	Ivor-Lewis operation	Lung cancer	[30]
Male	55	Primary repair for duodenal ulcer		[30]
Male	81	laparoscopic cholecystectomy, surgical repair of bilateral inguinal hernias with mesh placement	acute myocardial infarction, hypertension, surgery related ileus.	[31]
(78 male and 35 female)	NA	106 patients have had previous surgery for duodenal ulcer.	103 of 113 cases, reported persimmon ingestion prior to GI obstruction.	[32]
Female	19	No	Anorexia nervosa , Binge-purge , Hematemesis	[33]
(20 males, 24 females)	(55.36±15.17)	7 cases out of 44 patients, have had previous surgeries	Relatively older patients (55.36±15.17), Surgery (7 cases), Chronic diseases (13 cases)	[34]
90 Females & 63 M ales including (29 girls + 54 Boys)	Age range (2-80 Y	Only 10 surgery cases	18 cases (1 child, 17 adults) have predisposing factors: gastrointestinal strictures (10/153, 6.5%), diabetes (4/153, 2.6%) and neuropsychiatric disease (4/153, 2.6%).	[35]
Male		laparoscopic sleeve gastrectomy (SG)		[36]
5 Male, 9 Female	52 -82 Y	4 appendictomy (2F+2M), 1 hysterctomy, (1, M) gasterectomy, 1 ileus. +3 cases female cesarean resections	All patients had ingested rice cake by swallowing without chewing.	[37]
Female	93	distal gastrectomy and laparoscopic cholecystectomy	Ingestion of Kaky fruit	[38]
5 Male, 3 Female	62, 63, 68, 76, 85 (M); 56, 65, 83 (F)	abdominal syrgeries, 2 cases (1 m and 1F)	5 have dentures (3M+2F), 1 quick feeder, 1had operation, 1 operation and quick feeder (F)	[39]
Female	34Y	LAGB		[40]
Female	54Y	RYGB		[41]

Gender	Age (years)	previous surgery	Other risk factors & medical history	Ref.
4 Females, 5 Males	52-83 (mean age : 67.3),	5/9 had gastric surgery,	Aging, gastric surgery, Poor mastication, medications DM., hypertention + hyperlipidemia, Abdomino-perineal resection 1/9Unremarkable case (67 Y. old)	[42]
Female	51Y	RYGB		[43]
Hispanic Male	13Y.,	Appendectomy, 6 year ago.	large amount of white fibrous material of unclear etiology	[44]
Female	57 Y	RYGB		[45]
Female	34 Y,	laparoscopic Roux-en-Y gastric bypass (RYGB) due to class III morbid obesity	Morbid obesity	[46]
Male	57 Y.	Gastric laparotomy	Hypertension	[47]
Male	78	Gasterctomy	Diospyrobezoar	[48]
Male	34 Y,	RYGB		[49]
Female	49 Y	RYGB		[50]
Male	57 Y,	RYGB		[51]
Female	46 Y	RYGB		[51]
Male,	57 Y,	Laparoscopic Roux-en-Y gastric bypass	Morbid obesity, BMI of 44, hypertension, obstructive sleep apnea, and ventral hernia due to previous open cholecystectomy underwent laparoscopic gastric bypass	[51]
Female	46 Y	Laparoscopic Roux-en-Y gastric bypass	Morbid obesity, BMI of 44, hypertension, obstructive sleep apnea, and ventral hernia due to previous open cholecystectomy underwent laparoscopic gastric bypass	[51]
Male	70s Y.	open cholecystectomy	Rapid consumption an expiring bag of peanuts, without perfect chewing.	[52]
Female	66	pylorus-preserving gastrectomy	large amount of persimmon fruits	[53]
9Male/ 8Female	(44-80)	Appendicectomy (3 cases), Hysterectomy (4 cases)	Gulping habit (2case), toothless (1case),	[54]
Female	F, 86 Y., solid food bezoar	Cholecystectomy surgery	Ingestion of solid food bezoar	[55]
Japanese male,	56 Y.	pigtail-shaped PEG-J (percutaneous endoscobic transgastric jejunectomy) tube	Levodopa-carbidopa intestinal gel (LCIG) is an established device-aided therapy for patients with advanced Parkinson's disease (PD)	[56]
(7 Males, & 4 Females),	Age ranged between 42-74 Y olds ,	pigtail-shaped PEG-J (percutaneous endoscobic transgastric jejunectomy) tube	levodopa-carbidopa intestinal gel (LCIG) is an established device-aided therapy for patients with advanced Parkinson's disease (PD)	[56]
6 Males, 3 Females	50-65 (males), 36, 56, 69 (females)	All have had previous vagotomy and drainage procedures for duodenal ulcer.	Not mentioned	[57]
Female	47Y	RYGB		[58]
Female	37Y	LAGB		[58]
Female	42Y	LAGB		[59]
51 cases 27 Males : 24 Females	Median Age 62.9 (range: 27-89) years	Previous gastric surgery (n = 16, 31.4%) was the most common predisposing risk factor	Other predisposing factors: diabetes, hypertension, peptic ulcer, persimmon fruit, brown see weeds, and others	[60]

Gender	Age (years)	previous surgery	Other risk factors & medical history	Ref.
Female	21 Y	RYGB		[61]
Male	A 47-years	Yes	underwent a cholecystectomy 10 years ago the patient admitted to consuming a diet high in fibrous vegetables proton pump inhibitors	[62]
Female	59-year	Yes	Roux-en-Y gastric bypass (RYGB)	[63]
Male	67-Year	Yes	Prostatic cancer - radiotherapy	[147]
Female	45-Year	Yes,		[144]
Female	40-Year	Yes,	2 times Cholecystectomy	[137]

Table 2: List for diospyrobezoar (persimmon) cases.

Gender	Age	previous surgery	Risk factors & medical history	Ref.
96 cases (22 females , 74Males)	NA	no	NA	[64]
20 male and 1Female	40-76 Y	no	persimmon fruits	[65]
Male	73	no	persimmon fruits	[66]
(78 male and 35 female)	113 cases	106 patients have had previous surgery for duodenal ulcer.	103 of 113 cases, reported persimmon ingestion prior to GI obstruction.	[32]
Male,	35 Y.,	No	large quantity of unripe persimmons	[67]
49 Males +10 Females	2 -78 Y. (median 56)	Not mentioned	Eating persimmon's fruits	[68]
51 cases 27 Males : 24 Females	Median Age 62.9 (range: 27-89) years	Previous gastric surgery (n = 16, 31.4%) was the most common predisposing risk factor	Other predisposing factors: diabetes, hypertension,peptic ulcer, persimmon fruit (11 cases), brown see weeds (4cases), and others	[60]
Male	27	no	large amount of persimmon fruits	[69]
Girl	5-Years	No	Persimmon	[142]
Female	88-Years	No	Persimmon	[139]
Female	54-Years	No	Persimmon	[145]

Table 3- list for seed bezoar cases

Gender	Age (years)	phytobezoar Type	previous surgery	Other risk factors & medical history	Ref.
Male	78	Giant granadilla's seed bezoar (Passiflora quadrangularis)	no	essential hypertension and prostate benign hyperplasia	[70]
2 Males	6 &10	unshelled sunflower seeds and areca nuts.	No.	unshelled sunflower seeds and areca nuts.	[71]
Male	1.7	Male, 1.7 Y., seed shells	No	Hard fibrous plant material, (seed shells).	[72]

Gender	Age (years)	phytobezoar Type	previous surgery	Other risk factors & medical history	Ref.
16 Male/14 Female	Range: 19 - 79	prickly pear seeds (12 cases), watermelon seeds in (10), sunflower seeds (6), popcorn kernels (1) and pomegranate (1).	not specified	(5 cases) have predisposing factors: neurologic, psychiatric, or anal disorder, as well as previous surgery	[73]
18 Males/14 females (1.29/1).	32 cases, (range 17-78) years; Mean age was 53.73±15.56	32 cases phytobezoar ,	(19 of them have previous surgery.) 13 have had another predisposing factors.	Peptic ulcera (n = 4, 11.76%), diabetes mellitus (n = 4, 11.76%), cherrylaurel (Prunus Buricerasus) or persimmon (Diospyrus Lotus) intakes (n = 6, 17.64%), mental retardation-trichotillomania (n = 2, 5.88%), high dose intake of H2 receptor antagonists (n = 1, 2.94%) were also found in patients' history.	[20]
Female	21	phytobezoar (Food matter)	No	Bulimia nervosa Binge eating episodes	[74]
78 cases	NA	psyllium bezoar	No		[75]
Male	40	Mango seed bezoar	No	The patient was under the influence of alcohol, accidental ingestion of mango seed occurred.,	[76]
Male, Unemployed ,	50 Y	pumpkin seed bezoar.	No	-pumpkin seeds (about 400 gr.) with their shell.	[77]
Male	4y	undisegisted rhubarb	No	undigested rhubarb	[78]
43 cases (23 males and 20 females)	Range: 18-93	43 cases; Suffered from intestinal obstruction due to phytobezoars (40.5% persimmon's bezoars; and 43.6 % gauava's bezoars)	8 cases, (18.6%) Gastrectomy	Diabetes, dental problems, Stomach diseases accounted for 25.5%, 43.6%, 69.7% respectively.	[26]
Male	64	Man, 64 Y, phytobezoar due to unshelled sunflower seeds.	No	No	[79]
2 Males	13 & 6 years	unshelled sunflower seeds	No.	Have had consumed unshelled sunflower seeds	[80]
2 Males	8 &10 Y,	2 boys, 8 &10 Y, phytobezoar due to large amount of unshelled sunflower seeds	No	N.A.	[81]
Male	72	Male, 72 Y., Sunflower-fruits	No	large amount of fried, unshelled sunflower seeds	[82]
Male	12	Rectal bezoar sunflower seeds	No	200 grams of salted sunflower seeds with shells	[83]
16 Males/14 Females	19 - 79	unshelled watermelon seeds (10 cases),	not determined	(5 cases) have predisposing factors: neurologic, psychiatric, or anal disorder, as well as previous surgery	[73]
Male	7	seed bezoar watermelon	No	Unshelled watermelon seeds	[84]
Female	76	prickly pear seeds	No	diabetes, controlled only by diet, 40 prickly pear fruits with their seeds	[85]

Gender	Age (years)	phytobezoar Type	previous surgery	Other risk factors & medical history	Ref.
Male	48	a huge vegetable materials	No	hypertension and kidney failure , high fiber diet	[86]
Male	21	psyllium seed husk bezoar	No	Psyllium husk ingestion without andequate amount of fluid	[87]
95 cases of 103 (52 Males and 43 Females)	Mean Age (60.5±11.3) years	95 cases phytobezoar	gastric surgery (25.2%),	risk factors were history of gastric surgery (25.2%), diabetes mellitus (21.3%), hypothyroidism (15.5%), trichophagia (5.8%), and anxiety disorders (2.9%), respectively	[27]
Female,	43 Y,	43 Y, Female, (olive seeds phytobezoar)	No	• proton pump inhibitors, due to duodenal ulcer • pyloric stenosis	[88]
Male	49	Jujubes	No	Habitual jujubes ingestion	[89]
90 Females & 63 M ales including (29 girls + 54 Boys)	Age range (2-80 Y.). 54Boy+29 girl	153 cases of seed bezoar 55 cases (unshelled watermelon seeds), 30 unshelled sunflower seeds, 28 prickly pears, 11 willed banana seeds.5 unshelled pumpkin seeds, 4 pomegranate seeds. 2 cases have been reported for each of Date, olive pits, tangerine, lupin and popcorn seeds. While 1 case for granadilla, sesame, Baccaurea macrocarpa, jaboticaba, peanuts, lentil, cherry pits, box myrtle, mango seeds and freekeh grains.	No	18 cases (1 child, 17 adults) have adults) have predisposing factors: gastrointestinal strictures (10/153, 6.5%), diabetes (4/153, 2.6%) and neuropsychiatric disease (4/153, 2.6%).	[35]
Male	79	Sesame seed bezoar.	Yes	He underwent a sigmoid colectomy, with histology showing diverticular disease	[90]
Female, (housewife) .	41 Y.,	Phytobezoar formed of undigested vegetable matter (peas), fibrous material and decomposed food residue.	No surgery	No (may be poor physical exercise leads to GI laziness)	[91]
Boy	7 years	Ingestion of a large amount of unshelled broad beans.	No	No	[92]
4 Male cases	(15, 16, 22 &18)	Phytobezoar from jungle banana seeds	No	Ingestion of large quantity of jungle banana with seeds.	[93]
Girl	2 years	Excessive consumption of peas	No	No	[94]
Female	54	Fresh hawthorns 200-250 g every day for a year	No	fresh hawthorns 200-250 g every day for a year	[95]
Female	86	Phytobezoar due to apricot pits	No	she suffered from difficulties in chewing foods due to her denture,	[96]
Female	73	Phytobezoar due to apricot pits	No	She swallowed the pit accidently	[97]
Male	67	Nectarine pit	No	he swallowed the pit accidently	[98]
Male	86	Prune pit bezoar	Yes	He has had previous appendectomy	[22]
Boy	10-years	Seed besoar	No		[138]
Woman	60-years	Seed bezoar	No		[138]

Gender	Age (years)	phytobezoar Type	previous surgery	Other risk factors & medical history	Ref.
Man	25-Years	Guava bezoar	No		[148]
Female	45-Years	Coconut bezoar	yes		[144]

Table 4: list for phytobezoar cases due to bulk producers

Gender	Age (years)	phytobezoar Type	previous surgery	Other risk factors & medical history	Ref.
Male	50	bran	No	(two large Bowls of bran cereal with milk)	[99]
Female	84	Oat bezoar	No	dentureless, poor mustication, High fiber diet	[100]
Male	39	Chia seed	No	asthma and seasonal allergies	[101]
Female	41	psyllium seed bezoar	No	she swallowed dry psyllium seed	[102]
Female	14	Linseed bezoar	No	ingestion of great amount of linseed	[103]
Male	76	psyllium seed bezoar	No	ingestion of psyllium seed husk powder, Parkinson's disease	[104]
Man	66	karaya gum	No	This occurred after ingesting several tablespoons of a granular stool bulking laxative containing 62% karaya gum for chronic constipation, prior to reclining to sleep. He did not drink any liquids after ingesting these granules.	[105]
78 cases		phytobezoars or GIO due to ingestion of laxative drug formed mainly of psyllium seeds or psyllium seed husks.	No		[75]
Male	21	psyllium seed husks	No	He did not drink the required amount of fluids because he wasfasting.	[87]
Female	74	psyllium seed	No		[106]
Female	59	Agiolax® (psyllium seed, psyllium husks, senna pods)	No	body mass index (BMI) of 37.9 kg/m and multiple co-morbidities (hypertension, diabetes, hyperuricemia, hyperlipidemia, depression and osteoarthrosis of low back)	[107]
Male	91	Sterculia gums	No	after mistakenly swallowing a tablespoon of sterculia granules	[108]
Male	75	serutan® (psyllium granules)	No	Insufficient water intake after bulk-producer ingestion	[109]
Male	81	Psyllium-based Bulk laxative "Perdiem"	No	Insufficient water intake after bulk-producer ingestion	[110]
Male	72	Perdiem granules	No	Insufficient water intake after bulk-producer ingestion	[111]
Woman	67	Perdiem granules	No	Insufficient water intake after bulk-producer ingestion	[111]
Woman	41	Perdiem granules	No	Insufficient water intake after bulk-producer ingestion	[111]
Male	66	Plantago ovata seed (psyllium seed)	No	Insufficient water intake after bulk-producer ingestion	[112]
Male	56	Vegan diet, most probably chia seeds bezoar.	No	Strict vegan diet 15 Kg weight loss in 12 months.	[113]
Infant	1.5	Psyllium, beet & lentils		Down syndrome	[146]

Gender	Age (years)	phytobezoar Type	previous surgery	Other risk factors & medical history	Ref.
Man	50	Konjac bezoar			[141]
Man	60	Mushroom			[149]

Table 5: list for unusual food, pulpy and non-fibrous food bezoar cases

Gender	Age	phytobezoar Type	previous surgery	Risk factors & medical history	Ref.
Male	50 Y	Male, Fatty acids and Lecithin	No	No	[114]
Female	44 Y.	large amounts of honeycomb	No	Irritable bowel syndrome Consumption of large quantities of honeycomb for health benefits	[115]
Male	65 Y	Chestnuts phytobezoar	No	Chestnuts consumption	[116]
Male	61 Y.	Chestnuts phytobezoar	No	Consumption of large quantity of Chestnuts	[117]
Male	1.3 Y (16 months)	dried Apricots	No	whole dried apricots , inadequate mastication	[118]
Male	78 Y.	phytobezoar (undigested Apple pieces & whole maize grains)	No	abnormal mastication habits as well as a jejunal diverticulum	[119]
Male	86	pickled plume	No	accidently ingested japanese pickled plum with seeds.	[120]
Male	69	dried Apple	No	coronary arteries bypass, diabetes and hypertension. He had no teeth, and not used dentures for the past 10 years. Only chew various foods with his gums only. but admitted to swallowing food in whole occasionally.	[121]
Not specified	Not specified	150 cases, GI obstruction due to different types of phytobezoars (orange pulp, figs, apples, grapefruit, persimmons, coconuts, cabbage, beans and potatoes)	All have had previous gastrectomy for duodenal ulcer.		[9]
Female	62 Y.	phytobezoar	No	many years she had eating quite a substantial proportion of raw or poorly cooked long stemmed vegetables.	[122]
Male	4 Y.	Undigested rhubarb	no	undigested rhubarb	[78]

Gender	Age	phytobezoar Type	previous surgery	Risk factors & medical history	Ref.
Male	75	Meat bolus bezoar	No	Our patient had not gone under gastric surgery but recalled a right inguinal hernia repair40~ years ago, had a history of diabetes mellitus type II, and he wears a dental prosthesis which increases the possibility of bezoar formation in his GIT.	[123]
Female	59	swollwed whole potatoes	No	medical history of cerebral palsy due to birth hypoxia	[124]
Female	53	swallowed whole potatoes	No	Medical history of learning disability, autism and partial sightedness,	[124]
2 Males, 1 Female	0.25 - 0.3 Y (3-4 months)2 girl, 1 boy	potato bezoar	No	mashed potato	[125]
5 Male, 9 Female	52 -82 Y	Rice cake bezoar , 4 cases no surgery	(7 cases , 3 Male & 4 females) 4 appendictomy (2F+2M), 1 hysterctomy, (1, M) gasterectomy, 1 ileus. +3 cases female cesarian resections	All patients had ingested rice cake by swallowing without chewing.	[37]
5 Male, 3 Female	62, 63, 68, 76, 85 (M); 56, 65, 83 (F)	Rice cake bezoar, 6 cases no surgery	Yes, 2 cases (1 m and 1F*) abdominal syrgeries	5 have dentures (3M+2F), 1 quick feeder, 1had operation, 1 operation and quick feeder (F*)	[39]
Female	68 Y	Rice cake bezoar	No	She had eaten a toasted rice cake without chewing well because of her dentures the day before.	[126]
Female	59 Y	Rice cake bezoar	No	She had eaten a toasted rice cake without chewing well because of her dentures the day before.	[126]
Female	70 Y	Rice cake bezoar	No	She had dentures and had eaten a boiled rice cake 5 hours previously.	[126]
Male	37	Rice cake bezoar	No	He had eaten a boiled rice cake without chewing well the day before.	[126]

Gender	Age	phytobezoar Type	previous surgery	Risk factors & medical history	Ref.
Male	64	Potato, brussels sprouts, and broccoli	No	for obesity and prior cholecystectomy.	[127]
9 Males/ 8 Females	(44-80)	Rice cake bezoar, 10 cases with no surgery	Appendicectomy (3 cases), Hysterectomy (4 cases)	Gulping habit (2 cases), toothless (1case),	[54]

Table 6: list of phytobezoar cases due to chronic diseases or GI disorders

Gender	Age	phytobezoar Type	previous surgery	Risk factors & medical history	Ref.
1 Boy, 5 Girls	(12-18 Y)	Phytobezoar		Dysautonomia (6 patients)	[128]
Male	60	food bezoar	No	GI laziness and constipation due to khat consumption	[129]
Female	24	Giant phytobezoar	No	No expected risk factors., but most likely dyspepsia and hypoacidity (she mentioned consumption of antacids for three months before admission). These factors may causes delayed gastric emptying.	[130]
Housewife	41	phytobezoar formed of undigested vegetable matter (peas), fibrous material and decomposed food residue.	No	No (may be poor physical exercise leads to GI laziness)	[91]
Male	11	Boy, 11 Y., phytobezoar	No	Intellectual disability and seizure disorder	[131]
Female	21	phytobezoar (Food matter)		Bulimia nervosa Binge eating episodes	[74]
Male	48	a huge vegetable materials	No	hypertension and kidney failure , high fiber diet	[86]
Female	19	(Vegetable matter)	No	Anorexia nervosa , Binge-purge , Hematemesis	[40]
Girl	11	giant phytobezoar due to ileal duplication.	No	Ileal duplication.	[132]
Woman	59	phytobezoar	No	type 2 diabetes and hypertension	[133]
(20 males, 24 females)	(55.36±15.17)		7 cases out of 44 patients, have had previous surgeries	Chronic diseases (13 cases) out of 44 patients	[34]
90 Females & 63 M ales including (29 girls + 54 Boys)	Age range (2-80 Y.).		Only 10 surgery cases	gastrointestinal strictures (10 cases/153, 6.5%), diabetes (4 cases/153, 2.6%) and neuropsychiatric disease (4 cases/153, 2.6%).	[35]

Gender	Age	phytobezoar Type	previous surgery	Risk factors & medical history	Ref.
Man	57-years	phytobezoar	No	type 2 diabetes with autonomic neuropathy have impaired gastrointestinal emptying functions, increasing the retention time of food and causing phytobezoar	[134]
Man	84-years	phytobezoar	No	Ischemic HD, Coronary artery by-pass graft, heart failure, Dementia, diabetes, benign prostatic hypertrophy, bipolar disorder.	[140]
Girl	17-Years	phytobezoar	No	Chronic eating disorder	[136]
Male	67-Year	Phytobezoar	Yes	Surgery due to Prostatic cancer - radiotherapy	[147]
Boy	12-Years	phytobezoar	No	Meckel's diverticulum	[150]

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S2. Appendix

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Reported on page
TITLE			
Title	1	Identify Systematic Review	1
ABSTRACT			
Abstract	2	A structured summary	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	4,5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	5,6
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	5
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	NA
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	NA

Section and Topic	Item #	Checklist item	Reported on page
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	5,6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	5,6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	5,6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	5,6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	NA
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	6
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	7
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	7
Study characteristics	17	Cite each included study and present its characteristics.	S1 appendix
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	NA
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/ credible interval), ideally using structured tables or plots.	S1 appendix
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics	S1 appendix
	20b	Present results of all statistical syntheses conducted.	7-9
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	6
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	12-13
	23b	Discuss any limitations of the evidence included in the review.	13
	23c	Discuss any limitations of the review processes used.	13
	23d	Discuss implications of the results for practice, policy, and future research.	12-13

Section and Topic	Item #	Checklist item	Reported on page
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	-
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	NA
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	13
Competing interests	26	Declare any competing interests of review authors.	13
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	S1 appendix

***NA: Not applicable**