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ORIGINAL ARTICLE

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The national prevalence of disorders of gut brain interaction in the United Kingdom in comparison to their worldwide prevalence: Results from the Rome foundation global epidemiology study

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Abstract

Background: There are minimal epidemiological data comparing the burden of disorders of gut brain interaction (DGBI) in the UK with other countries. We compared the prevalence of DGBI in the UK with other countries that participated in the Rome Foundation Global Epidemiology Study (RFGES) online.

Methods: Participants from 26 countries completed the RFGES survey online including the Rome IV diagnostic questionnaire and an in-depth supplemental questionnaire with questions about dietary habits. UK sociodemographic and prevalence data were compared with the other 25 countries pooled together.

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Key Results: The proportion of participants with at least one DGBI was lower in UK participants compared with in the other 25 countries (37.6% 95% CI 35.5%–39.7% vs. 41.2%; 95% CI 40.8%–41.6%, $p=0.001$). The UK prevalence of 14 of 22 Rome IV DGBI, including irritable bowel syndrome (4.3%) and functional dyspepsia (6.8%), was similar to the other countries. Fecal incontinence, opioid-induced constipation, chronic nausea and vomiting, and cannabinoid hyperemesis ($p<0.05$) were more prevalent in the UK. Cyclic vomiting, functional constipation, unspecified functional bowel disorder, and proctalgia fugax ($p<0.05$) were more prevalent in the other 25 countries. Diet in the UK population consisted of higher consumption of meat and milk ($p<0.001$), and lower consumption of rice, fruit, eggs, tofu, pasta, vegetables/legumes, and fish ($p<0.001$).

Conclusions and Inferences: The prevalence and burden of DGBI is consistently high in the UK and in the rest of the world. Opioid prescribing, cultural, dietary, and lifestyle factors may contribute to differences in the prevalence of some DGBI between the UK and other countries.

KEYWORDS
disorders of gut brain interaction, epidemiology, functional dyspepsia, irritable bowel syndrome, quality of life

1 | INTRODUCTION

The Rome Foundation Global Epidemiological Study (RFGES) spanning six continents provided the most comprehensive worldwide data on the prevalence of all 22 Rome IV disorders of gut–brain interaction (DGBI).[1] The global prevalence of these disorders was found to be high, with 40.3% of participants meeting criteria for at least one DGBI.[1] Aside from the overall global prevalence of DGBI and their interactions and overlap, the original study has, importantly, captured data on the burden and impact of these conditions with data on healthcare utilization and impact on quality-of-life worldwide. These data have not only been important in raising awareness of just how prevalent DGBI are on a worldwide scale but have also provided unique opportunities to understand how the prevalence of DGBI may vary amongst countries, and examining sociodemographic factors that may contribute to epidemiological differences, including dietary practices. The first country-level analysis of the RFGES dataset provided detailed national prevalence data for all 22 DGBIs in Israel, and compared the prevalence, healthcare utilization, and quality-of-life data with the other 25 countries that completed the questionnaire using the same Internet-based methodology.[2] However, to our knowledge, no studies have previously compared the epidemiology of DGBI in the UK with their epidemiology worldwide.

In the UK, despite DGBI accounting for a significant proportion of gastroenterology outpatient workload,[3] and substantial direct financial costs estimated to be between £1.3 and £2 billion for irritable bowel syndrome (IBS) alone,[4] these chronic disorders are given low priority in the gastroenterology training curriculum,[5–7] are of limited priority for research funding,[8] and there are only a few specialized centers nationally that offer integrated multidisciplinary care for DGBI, despite this being recognized increasingly as the standard of care.[9] Recently updated evidence-based national DGBI guidelines from the British Society of Gastroenterology on IBS and functional dyspepsia (FD) have emphasized the role of making positive diagnoses, and use of sequential first-, second-, and third-line therapies,

Key points

- Disorders of gut brain interaction (DGBI) are highly prevalent and burdensome in the UK and worldwide with significant effects on quality-of-life, psychological health, and healthcare utilization.
- Most DGBI, including irritable bowel syndrome and functional dyspepsia, have similar prevalence in the UK to the rest of the world.
- Opioid-induced constipation, chronic nausea and vomiting, and cannabinoid hyperemesis are more prevalent in the UK, whereas functional constipation and unspecified functional bowel disorders are more prevalent in other countries.
- Sociodemographic factors including environmental factors, British cultural, lifestyle and dietary practices, and opioid use may contribute to some of the variance in DGBI prevalence between the UK and other countries.

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with an emphasis on developing multidisciplinary services, including trained dietitians and behavioral gut–brain therapists.[10,11]

Although recent data from Australia suggest that the development of integrated multidisciplinary services is likely to be more cost-effective and efficacious compared with gastroenterologist-only care,[12,13] there are a lack of detailed national epidemiological data on DGBI in the UK in comparison with other countries. Such data would improve the understanding of the national epidemiology and impact of DGBI in the UK in comparison with other countries, and to understand population-specific factors that may influence prevalence, treatments, and outcomes. Detailed UK epidemiological data would therefore be of importance in planning future service development, including resource allocation on a national level to provide the standards of care recommended in the recently published national guidelines.

The aims of this study, therefore, were to compare the burden and prevalence of DGBI in the UK with that in the other 25 countries that participated in the online part of the RFGES. We also aimed to compare factors that may influence DGBI prevalence between the UK and other countries, including dietary intake, socioeconomic, sociodemographic, and demographic factors.

2 | MATERIALS AND METHODS

2.1 | Data collection

The UK was one of the 26 countries in the RFGES where data were collected by an anonymous Internet survey. The methodology for the RFGES has been described in depth elsewhere.[1] The other 25 countries that participated online were as follows: Argentina, Australia, Belgium, Brazil, Canada, China, Colombia, Egypt, France, Germany, Holland, Israel, Italy, Japan, Mexico, Poland, Romania, Russia, South Africa, South Korea, Singapore, Spain, Sweden, Turkey, and the United States. The online survey was conducted using an Internet survey platform (Qualtrics, LLC, Provo, Utah, USA).

2.2 | Study populations

The participants from all 26 countries were selected based exclusively on demographic characteristics as defined in the prespecified study parameters, which included at least 2000 participants, 50% female participants and 50% male participants, with 40% aged 18–39 years, 40% aged 40–64 years, and 20% aged 65+ years, with a representative national geographic distribution. The survey had multiple built-in quality-assurance measures to exclude poor-quality responders and minimize the risk of missing data or incorrect values. The electronic questionnaire included electronic informed consent. Ethical review was completed for all countries taking part in the RFGES, and formal ethical approval was waived for the UK and for the other Internet countries by the internal review board of the University of North Carolina at Chapel Hill, the United States, where the data collection was coordinated, as the data collected were totally anonymous to investigators with no means of identification in the present or future.

2.3 | Study questionnaire

The study questionnaire included the entire Rome IV Adult Diagnostic Questionnaire,[14] sociodemographic items, and questions on factors potentially associated with the prevalence of DGBI including living conditions, nutrition and diet, healthcare utilization (doctor visits, medications, and abdominal surgeries), stress, concern about bowel function, anxiety, depression, and other psychosocial factors. It also included the IBS Severity Scoring System (IBS-SSS),[15] the Patient Health Questionnaire-12 (PHQ-12), a screening tool for somatoform symptom-reporting,[16] the Patient Health Questionnaire-4 (PHQ-4)[17] for anxiety and depression, and the PROMIS Global-10 Questionnaire (range 4–20), part of the Patient-Reported Outcomes Measurement Information System (PROMIS), a publicly available global health assessment tool that measures the physical and mental health aspects of a person's overall quality of life.[18] In terms of dietary intake, participants from all 26 countries were asked on their frequency of intake of 10 food types (rice, milk, eggs, bread, pasta, meat, fruits, tofu, vegetables/legumes, and fish). Intake of each of these types of food was assessed in terms of average days per week of consumption. For the purposes of further analyses, food consumption was categorized into three categories based on frequency of intake of these food types: “don't eat” (participants that do not consume this food type at all), “eat some” (those that consumed the food type 1–3 days per week), and “eat often” (those that consume the food type ≥4 days per week).

2.4 | Adjusting for possible organic disease

Consistent with the approach taken in the previously published RFGES papers,[1,2] individuals with known organic gastrointestinal disease were excluded from meeting the criteria for a DGBI in this study. To reduce the chances of overestimation of the prevalence of DGBI, participants were asked whether they had ever been diagnosed by a doctor with any of a list of organic gastrointestinal diseases or had undergone bowel resection. Respondents with celiac disease, gastrointestinal cancer, or inflammatory bowel disease (Crohn's disease or ulcerative colitis) were excluded from all Rome IV DGBI diagnoses. Patients with peptic ulcer disease were excluded from esophageal, gastroduodenal, and biliary diagnoses. Finally, subjects with a history of diverticulitis or bowel resection were excluded from diagnosis of bowel and anorectal disorders.[1] Those who were disqualified for a DGBI were kept in the study analyses as participants who did not meet diagnostic criteria for DGBI. The proportion of participants excluded from DGBI eligibility due to having a

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known organic GI condition was similar (2.6% in the UK cohort vs. 2.9% in the other 25 countries).

2.5 | Statistical methods

Descriptive statistics and a *z*-test for the prevalence of each of the 22 DGBI and "any DGBI" were reported. Prevalence rates were pooled across the other 25 countries using the Yang's meta-prevalence method.[19] Univariate analyses examined the association between age and gender along with sociodemographic factors (community size, religion type, relationship status, frequency of consuming food types, doctor visits, Global Physical/mental Health component score, and years of education) and psychosocial variables with the presence of any DGBI and specific DGBI in UK alone and in the other 25 Internet countries. To determine the statistical difference between categorical variables, chi-squared tests were used, and *p*-values are presented along with proportions and 95% confidence intervals.[20] Meta-analysis with random effects was used to estimate the overall prevalence and test the differences in prevalence between the other 25 countries and the UK.[21] Descriptive statistics of overlapping DGBI prevalence rates was performed for the UK alone and for the other 25 Internet countries together. Graphical display of proportions of disorders by country was achieved using the R package metafor version 4.1.3.[22] Analyses were carried out using R statistical programming environment.[23]

3 | RESULTS

Some of the data in this paper have already been reported in previous RFGES papers.[1,2] This is inevitable since the original paper included a broad range of descriptive statistics for all countries ($N=33$) and all DGBI ($N=22$).[1] Other papers, including the present one, which use the same database, are reporting in-depth analyses for countries, disorders, and methods, and these include a brief overview of some specific data previously reported. Overall, the number of participants in the UK was 2027 and 52,100 in the other 25 countries, with almost identical gender distributions in both groups (Table S1).

3.1 | Sociodemographic factors

There were some sociodemographic differences between the UK survey sample and the other 25 countries surveyed, which are likely to be representative of UK national sociodemographic. The UK sample included more participants in the older age bracket, with fewer 18- to 39-year-olds compared with the other 25 countries pooled (Table S1). There were also population-specific differences in religious beliefs, marital status, type of area lived in, and education status in the UK population, compared with the 25 countries pooled together (Table S1).

3.2 | Overall DGBI prevalence for the UK and the other 25 countries pooled together

The prevalence rate of having any DGBI and each of the 22 DGBI in the UK, compared with the pooled prevalence in the other 25 countries, is presented in Table 1 and Figure 1. The overall prevalence rate of having a DGBI in the other 25 countries pooled was higher at 41.2% (95% CI 40.8%–41.6%) compared with 37.6% (95% CI 35.5%- 39.7%) in the UK ($p=0.001$). Prevalence rates for having at least one DGBI were similar across all geographical regions within the UK ranging from 31.9% in Southeast England to 42.1% in the Midlands (Figure 2).

In the UK, 64.4% of those with a DGBI met diagnostic criteria for only one DGBI, while 35.6% met diagnostic criteria for a DGBI in two, three, or four anatomic GI regions (Figure 3A). Similarly, in the other 25 countries, 66.9% met diagnostic criteria for only one DGBI, while 33.1% met diagnostic criteria for DGBI in two, three, or four anatomic regions (Figure 3B).

3.3 | DGBI with similar prevalence in the UK compared with the other 25 countries pooled together

The prevalence of 14 of the 22 DGBI was similar between the UK and the other 25 countries pooled together (Table 1). Disorders of gut brain interaction with similar prevalence included IBS, which had a UK prevalence of 4.3% (95% CI 3.4–5.2%) compared with 4.5% (95% CI 4.3%–4.7%) in the other 25 countries pooled (Figure 4A). The UK prevalence of FD, which was 6.8% (95% CI 7.9%–5.7%), did not differ from the 7.8% (95% CI 7.6%–8.0%) prevalence in the 25 countries pooled (Figure 4B). Other disorders with similar prevalence rates to the 25 pooled countries included all five esophageal DGBI (functional heartburn, reflux hypersensitivity, functional chest pain, globus, and functional dysphagia), rumination syndrome, belching, functional diarrhea, functional bloating, and levator ani syndrome. There were very few cases of either centrally mediated abdominal pain or functional biliary disorders in all 26 countries, with no differences in prevalence between the UK and the 25 countries pooled (Table 1).

3.4 | DGBI with different prevalence in the UK compared with the other 25 countries pooled together

Chronic nausea and vomiting, cannabinoid hyperemesis, opioid-induced constipation, and fecal incontinence were more prevalent in the UK compared with the 25 countries pooled (Table 1). By contrast, cyclic vomiting, functional constipation, unspecified functional bowel disorder, and proctalgia fugax had a higher prevalence in the 25 countries pooled (Table 1).

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TABLE 1 Comparisons between the UK and the 25 other countries pooled together for percentage prevalence of the 22 Rome IV DGBI according to anatomical regions.

Overall (*N* = 54,127)	UK (*N* = 2027)	Other 25 countries (*N* = 52,100)	*p*
Overall prevalence any DGBI (%)	37.6 (35.5–39.7)	41.2 (40.8–41.6)	0.001
Any Esophageal DGBI % (95% CI)	7.7 (6.5–8.9)	6.3 (6.1–6.5)	0.009
Functional heartburn	1.6 (1.1–2.2)	1.2 (1.1–1.3)	0.184
Reflux hypersensitivity	1 (0.6–1.4)	0.9 (0.8–1.0)	0.654
Functional chest pain	1.8 (1.2–2.4)	1.4 (1.3–1.5)	0.211
Globus sensation	0.9 (1.3–0.5)	0.8 (0.7–0.9)	0.633
Functional dysphagia	3.7 (2.9–4.5)	3.4 (3.2–3.6)	0.468
Any Gastroduodenal DGBI % (95% CI)	10.4 (9.1–11.7)	11.4 (11.1–11.7)	0.196
Functional dyspepsia	6.75 (5.7–7.9)	7.8 (7.6–8.0)	0.087
Belching	1 (0.6–1.4)	1.1 (1.0–1.2)	0.974
Rumination	2.9 (2.2–3.6)	2.9 (2.8–3.0)	0.928
Chronic nausea and vomiting	1.5 (1.0–2.0)	1 (0.9–1.1)	0.029
Cyclic vomiting	0.7 (0.3–1.1)	1.3 (1.2–1.4)	0.022
Cannabinoid hyperemesis	0.2 (0.0–0.4)	0	0.022
Any Bowel DGBI % (95% CI)	30.2 (28.2–32.2)	34.8 (34.4–35.2)	<0.001
Irritable bowel syndrome	4.3 (3.4–5.2)	4.5 (4.3–4.7)	0.753
Functional constipation	8.7 (7.5–9.9)	12.2 (12.5–11.9)	<0.001
Opioid-induced constipation	2.7 (2.0–3.4)	1.7 (1.6–1.8)	0.001
Functional diarrhea	4.5 (3.6–5.4)	4.9 (4.7–5.1)	0.523
Bloating/distention	3.9 (3.1–4.7)	3.4 (3.2–3.6)	0.223
Unspecified functional bowel Disorder	7.0 (5.9–8.1)	9.2 (9.0–9.5)	0.001
Any Anorectal DGBI % (95% CI)	8.2 (7.0–9.4)	8.3 (8.1–8.5)	0.968
Fecal incontinence	2.7 (2.0–3.4)	1.7 (1.6–1.8)	0.001
Levator ani syndrome	1.6 (1.1–2.2)	1.3 (1.2–1.4)	0.176
Proctalgia fugax	4.9 (4.0–5.8)	6.0 (5.8–6.2)	0.046
Centrally mediated abdominal pain syndrome	0	0	0.939
Functional biliary pain	0	0.1 (0.1–0.1)	0.342
Number of DGBI per participant			
No DGBI	62.3 (60.2–64.4)	58 (57.6–58.4)	<0.001
1 DGBI	21.7 (19.9–23.5)	25.3 (24.9–25.7)	
2 DGBI	8.5 (7.3–9.7)	8.9 (8.7–9.1)	
3 or more DGBI	7.5 (6.4–8.6)	7.8 (7.6–8.0)	

Note: The green colour shades are the group means for each category of DGBI.

3.5 | DGBI prevalence rates in the UK and the other 25 countries pooled together by anatomical region

In the UK and the 25 countries pooled, bowel disorders were the most prevalent DGBI, followed by gastroduodenal disorders, anorectal disorders, and then esophageal disorders (Table 1). Overall, esophageal DGBI were more prevalent in the UK, whereas bowel DGBI had a higher pooled prevalence in the other 25 countries (Table 1 and Figures S1 and S2). However, the UK prevalence of gastroduodenal and anorectal disorders did not differ (Table 1).

3.6 | Distribution of IBS and FD subtypes in the UK and the other 25 countries pooled together

Overall IBS and FD prevalence and subtype prevalence rates were similar between the UK and the 25 countries pooled (Table 2). The male prevalence of IBS in the UK of 1.2% (95% CI 0.7%–1.7%) was similar to the 1.7% (95% CI 1.6%–1.8%) pooled prevalence amongst males from the other 25 countries, $p = 0.10$. Similarly, the prevalence of IBS in females did not differ between the UK and the 25 countries pooled: 3.1%; 95% CI 2.3%–3.9% vs. 2.8%; 95% CI 2.6%–2.9%, $p = 0.44$.

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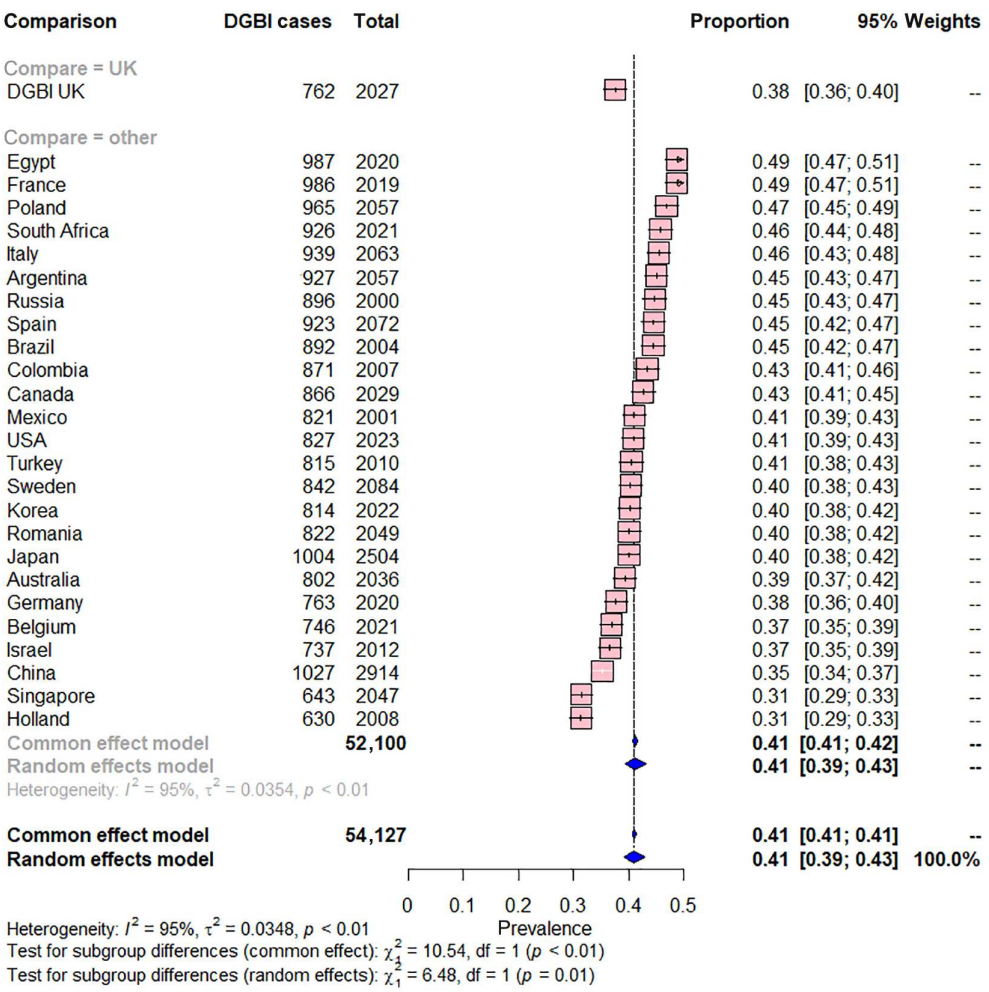

FIGURE 1 Forest plot displaying proportions of DGBI across the other 25 countries pooled compared with the UK.

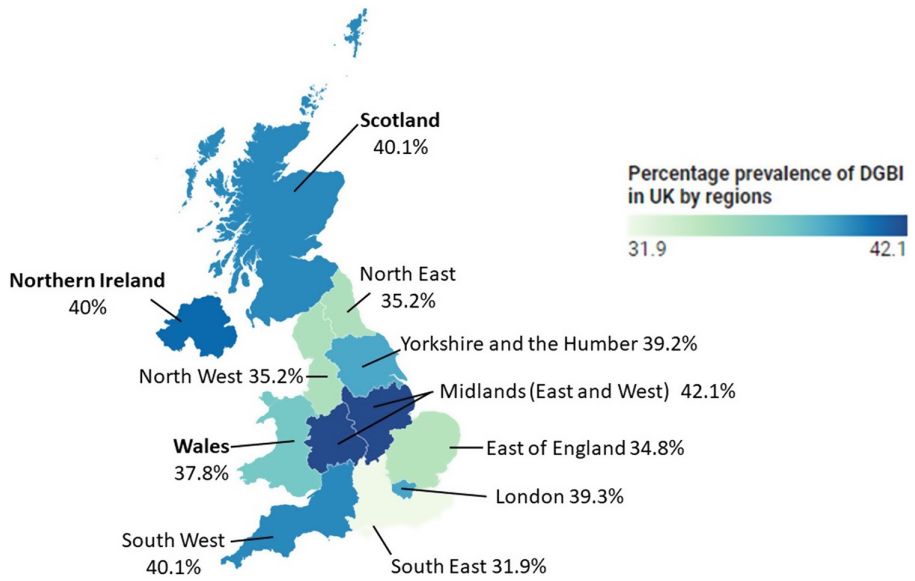

FIGURE 2 National prevalence of having any DGBI by geographical region in the UK.

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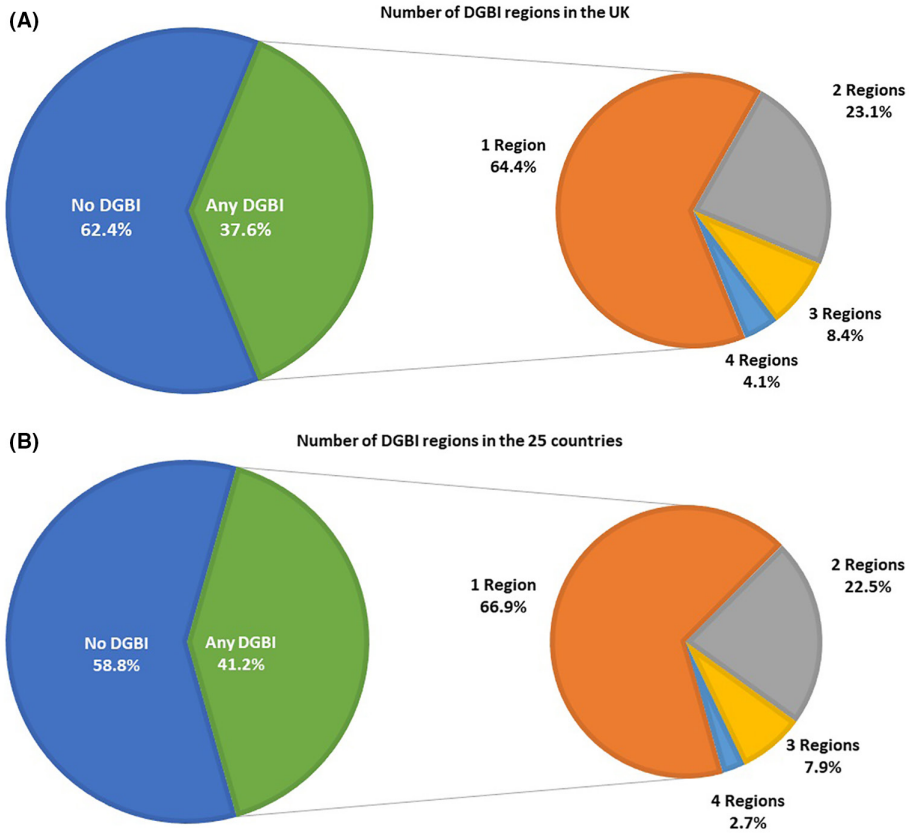

FIGURE 3 DGBI in overlapping anatomical regions (A) in the UK (B) in the other 25 countries pooled.

3.7 | Comparison of IBS severity between the UK and the other 25 countries pooled together

Irritable bowel syndrome severity in the UK tended to be higher than most other countries surveyed and was ranked third highest amongst the 26 countries surveyed in terms of severity, only behind Columbia and Mexico (Figure S3). However, the mean IBS-SSS was similar to that in the 25 pooled countries: (268.51 (SD 102.5) vs. 250.9 (SD 103.9), $p=0.118$). However, male IBS was more severe in the UK than in the pooled 25 countries (287.5 (SD 103.3) vs. 239.5 (SD 103.6), $p=0.025$), whereas female IBS had similar severity (261.3 vs. 257.8, $p=0.79$).

3.8 | Dietary intake in the UK compared with the other 25 countries pooled together

Food pattern and frequency varied between the UK and the 25 countries pooled for all 10 food groups that were surveyed (summarized in Table S2 and Table 3). Frequent milk and meat consumption was higher amongst UK participants. Whilst frequent rice, eggs, tofu, and pasta intake were more common dietary constituents in the other 25 countries (Table 3). A higher proportion of UK participants reported not eating vegetables, legumes, and fruits at all; meanwhile, moderate vegetable, legumes, and fruit consumption was higher amongst participants from the other 25 countries (Table 3). Fish consumption frequency is also different in the UK, with a higher proportion of UK participants reporting that they "never" eat fish, and a lower proportion in the UK reporting that they eat fish ≥4 days per week.

3.9 | The burden of DGBI in the UK and the other 25 countries pooled together

Meeting diagnostic criteria for any DGBI in the UK was associated with younger age, female gender, marital status, healthcare utilization (more frequent doctor visits regarding both general health and bowel problems, number of abdominal surgeries, and medication use), physical and mental quality of life on the PROMIS Global-10, anxiety and depression on the PHQ4, somatoform symptom-reporting on the PHQ12, sensitivity to stress, pressure and tension on bowel function, and concerns about bowel function (Table 4).

4 | DISCUSSION

This study has provided the most comprehensive evaluation of the epidemiology of DGBI in the UK to date providing insight into the burden of DGBI, and how it compares with the worldwide epidemiology of these disorders. The overall prevalence of DGBI in the UK (37.6%) and the pooled prevalence in the other 25 countries (41.2%) were both found to be high. In both the UK and in the other

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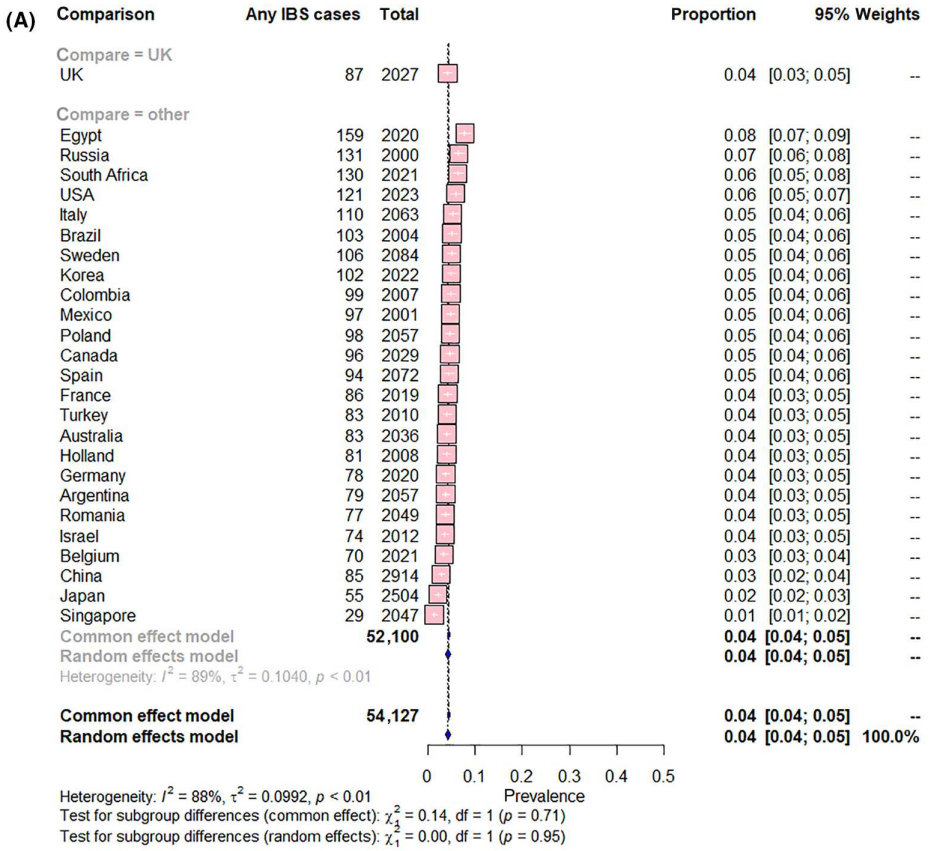

FIGURE 4 Forest plots comparing the prevalence of (A) irritable bowel syndrome (B) functional dyspepsia between the UK and the other 25 countries pooled.

25 countries pooled, DGBI were found to be associated with higher healthcare utilization, impaired physical and mental health related quality of life, anxiety and depression, somatoform symptom-reporting, concerns about bowel function, and the effects of stress and pressure on bowel function.

Although the overall prevalence of DGBI in the UK was slightly lower than the pooled prevalence in the other 25 countries, it is unlikely that the small differences in overall prevalence are clinically relevant, for two reasons. First, the confidence interval ranges for both the prevalence estimates in the UK and the pooled prevalence

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TABLE 2 Comparisons between the UK and the other 25 countries for irritable bowel syndrome and functional dyspepsia subtypes.

ROME IV IBS, FD and subtype prevalence	UK% (95% CI)	Other 25 countries % (95% CI)	*p*
Overall IBS prevalence	4.3 (3.4–5.2)	4.5 (4.3–4.7)	0.753
IBS subtype % (95% CI)			
IBS-C	1.4 (0.9–1.9)	1.4 (1.3–1.5)	0.873
IBS-D	1.1 (0.7–1.6)	1.3 (1.2–1.4)	
IBS-M	1.4 (0.9–2.0)	1.5 (1.4–1.6)	
IBS-U	0.3 (0.1–0.6)	0.3 (0.2–0.3)	
Overall FD prevalence	6.8 (5.7–7.9)	7.8 (7.6–8.0)	0.087
FD subtype % (95% CI)			
Postprandial Distress + epigastric pain	1.3 (0.8–1.8)	1.5 (1.4–1.6)	0.55
Epigastric pain	1.1 (0.7–1.6)	1.2 (1.1–1.3)	0.71
Postprandial distress	4.3 (3.4–5.2)	5.1 (4.9–5.3)	0.10

TABLE 3 Prevalence of food pattern categorized as (don't eat/eat some/eat often) for the UK compared with the other 25 countries.

Food variable	Category	UK % (95% CI)	Other 25 countries % (95% CI)	*p*
Rice (%)	Don't eat	15.6 (14.0–17.2)	7.6 (7.4–7.8)	<0.001
	Eat some	75.6 (73.7–77.5)	57.1 (56.7–57.5)	
	Eat often	8.8 (7.5–10.0)	35.3 (34.9–35.7)	
Meat (%)	Don't eat	6.4 (5.3–7.5)	3.8 (3.6–4.0)	<0.001
	Eat some	30.2 (28.2–32.2)	38.5 (38.1–38.9)	
	Eat often	63.3 (61.2–65.4)	57.7 (57.3–58.1)	
Breads (%)	Don't eat	3.2 (2.4–4.0)	3.6 (3.4–3.8)	0.631
	Eat some	27.5 (25.6–29.4)	27.5 (27.1–27.9)	
	Eat often	69.4 (67.4–71.4)	68.9 (68.5–69.3)	
Milk (%)	Don't eat	3.9 (3.1–4.7)	5.1 (4.9–5.3)	<0.001
	Eat some	17.5 (15.9–19.2)	31 (30.6–31.4)	
	Eat often	78.6 (76.8–80.4)	63.8 (63.4–64.2)	
Fruits (%)	Don't eat	7 (5.9–8.1)	4.6 (4.4–4.8)	<0.001
	Eat some	26.6 (24.7–28.5)	33.2 (32.8–33.6)	
	Eat often	66.4 (64.3–68.5)	62.2 (61.8–62.6)	
Fish (%)	Don't eat	17.5 (15.9–19.2)	16.9 (16.6–17.2)	<0.001
	Eat some	76.8 (75.0–78.6)	73.3 (72.9–73.7)	
	Eat often	5.7 (4.7–6.7)	9.8 (9.5–10.1)	
Veg/legumes (%)	Don't eat	2.3 (1.7–3.0)	1.6 (1.5–1.7)	<0.001
	Eat some	19.4 (17.7–21.1)	25 (24.6–25.4)	
	Eat often	78.3 (76.5–80.1)	73.4 (73.0–73.8)	
Tofu (%)	Don't eat	91.5 (90.3–92.7)	72.4 (72.0–72.8)	<0.001
	Eat some	6.7 (5.6–7.8)	20.3 (20.0–20.7)	
	Eat often	1.8 (1.2–2.4)	7.3 (7.1–7.5)	
Pasta (%)	Don't eat	14.3 (12.8–15.8)	13.5 (13.2–13.8)	<0.001
	Eat some	75.4 (73.5–77.3)	66.4 (66.0–66.8)	
	Eat often	10.3 (9.0–11.6)	20.1 (19.8–20.4)	
Eggs (%)	Don't eat	13.2 (11.7–14.7)	6.1 (5.9–6.3)	<0.001
	Eat some	71.8 (69.8–73.8)	63.3 (62.9–63.7)	
	Eat often	15 (13.5–16.6)	30.6 (30.2–31.0)	

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TABLE 4 Comparison of the association of sociodemographic and psychosocial variables amongst participants with and without any DGBI, in the UK and in the other 25 countries.

	UK ($N = 2027$)			Other 25 countries ($N = 52,100$)		
Variables	No DGBI ($N = 1265$)	Any DGBI ($N = 762$)	p	No DGBI ($N = 30,629$)	Any DGBI ($N = 21,471$)	p
Age category % (95% CI)						
18–39	37.1 (34.4–39.8)	44.4 (40.9–47.9)	<0.001	40.1 (39.6–40.7)	46.2 (45.5–46.9)	<0.001
40–64	38.8 (36.1–41.5)	42.1 (38.6–45.6)		41.8 (41.3–42.4)	40.4 (40.0–41.1)	
65+	24.1 (21.7–26.5)	13.5 (11.1–15.9)		18.1 (17.7–18.5)	13.4 (12.9–13.9)	
Gender % (95% CI)						
Male	55.9 (53.2–58.6)	40.8 (37.3–44.3)	<0.001	56.2 (55.6–56.8)	43.4 (42.3–44.1)	<0.001
Female	44.1 (41.4–46.8)	59.2 (55.7–62.7)		43.8 (43.2–44.4)	56.6 (55.9–57.3)	
Religion % (95% CI)						
Other religions	8.7 (7.2–10.3)	10.8 (8.6–13.0)	0.002	20.5 (20.1–21.0)	20.6 (20.1–21.1)	<0.001
Christian	31.1 (28.6–33.7)	29 (25.8–32.2)		37.1 (36.6–37.6)	37.9 (37.3–38.6)	
No religion but believe in higher power	15.5 (13.5–17.5)	21.5 (18.6–24.4)		14.3 (13.9–14.7)	16.6 (16.1–17.1)	
Non-religious	37.6 (34.9–40.3)	32.8 (29.5–36.1)		20.8 (20.4–21.3)	19.5 (19.0–20.0)	
No answer	7 (5.6–8.4)	5.9 (4.2–7.6)		7.2 (6.9–7.5)	5.5 (5.2–5.8)	
Area type % (95% CI)						
City	33.9 (31.3–36.5)	35.7 (32.3–39.1)	0.501	67.1 (66.6–67.6)	68.5 (67.9–69.1)	<0.001
Town	42.8 (40.0–45.5)	43.7 (40.2–47.2)		23.2 (22.7–23.6)	22.8 (22.2–23.4)	
Village	20.9 (18.7–23.1)	18.1 (15.4–20.8)		7.1 (6.8–7.4)	6.7 (6.4–7.0)	
Countryside	2.5 (1.6–3.4)	2.5 (1.4–3.6)		2.5 (2.3–2.7)	2 (1.8–2.2)	
Marital status % (95% CI)						
Single	25.8 (23.4–28.2)	27.6 (24.4–30.8)	0.007	28.5 (2.0–29.0)	29 (28.4–29.6)	<0.001
Married	47 (44.3–49.8)	42.9 (39.4–46.4)		51.3 (50.7–51.9)	48.9 (48.2–49.6)	
Divorced	8.6 (7.1–10.2)	7.7 (5.8–9.6)		6.6 (6.3–6.9)	7.3 (7.0–7.7)	
Widowed	3.8 (2.8–4.9)	2.1 (1.1–3.1)		2.9 (2.7–3.1)	2.4 (2.0–2.6)	
Partnered	14.8 (12.8–16.8)	19.7 (16.9–22.5)		10.6 (10.3–10.9)	12.5 (12.1–12.9)	
Education level % (95% CI)						
Low	1.7 (1.0–2.4)	2 (1.0–3.0)	0.688	8 (7.7–8.3)	8.6 (8.2–9.0)	<0.001
Medium	70.2 (67.7–72.7)	68.6 (65.3–71.9)		67.1 (66.6–67.6)	65.3 (64.7–65.9)	
Other higher education	28.1 (25.2–30.6)	29.4 (26.2–32.6)		24.9 (24.4–25.4)	26.1 (25.5–26.7)	
How often do you go to a doctor for your health? % (95% CI)						
Once a month or more	4.7 (3.5–5.9)	14.8 (12.3–17.3)	<0.001	9.9 (9.6–10.2)	15.7 (15.2–16.2)	<0.001
A few times a year	42.7 (40.0–45.4)	50 (46.5–53.6)		49.5 (48.9–50.1)	52.9 (52.2–53.6)	
Once a year	20.3 (18.1–22.5)	14.7 (12.2–17.2)		17.2 (16.8–17.6)	13.4 (12.9–13.9)	
Less than once a year	29.2 (26.7–31.7)	18.5 (15.7–21.3)		19.7 (19.3–20.2)	15.2 (14.7–15.7)	
Never	3.2 (2.2–4.2)	2 (1.0–3.0)		3.7 (3.5–3.9)	2.8 (2.6–3.0)	
Doctor visits regarding bowel problem?						
No	81.8 (79.7–83.9)	56.8 (53.3–60.3)	<0.001	73.3 (72.8–73.8)	52.7 (52.0–53.4)	<0.001
Yes	18.2 (16.1–20.3)	43.2 (39.7–46.7)		26.7 (26.2–27.2)	47.3 (46.6–48.0)	
PROMIS-10 mental mean ± SD	14.4 ± 3.5	12.0 ± 3.7	<0.001	14.3 ± 3.1	12.6 ± 3.3	<0.001
PROMIS-10 physical mean ± SD	15.5 ± 2.7	13.1 ± 3.2	<0.001	15.2 ± 2.5	13.5 ± 2.6	<0.001

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TABLE 4 (Continued)

Variables	UK (N = 2027) No DGBI (N = 1265)	UK (N = 2027) Any DGBI (N = 762)	p	Other 25 countries (N = 52,100) No DGBI (N = 30,629)	Other 25 countries (N = 52,100) Any DGBI (N = 21,471)	p
Number of medications mean ± SD	0.6 ± 1.0	1.7 ± 1.8	<0.001	0.8 ± 1.3	1.7 ± 1.8	<0.001
PHQ12 ± SD	3.9 ± 3.2	6.9 ± 3.7	<0.001	4.3 ± 3.4	7.0 ± 3.9	<0.001
PHQ-4 ± SD	1.7 ± 2.6	3.9 ± 3.7	<0.001	2.0 ± 2.5	3.8 ± 3.2	<0.001
Number of abdominal surgeries ± SD	0.2 ± 0.5	0.3 ± 0.6	<0.001	0.3 ± 0.6	0.4 ± 0.6	<0.001
Does stress, pressure or tension affect your bowel functioning? % (95% CI)						
Not at all	70.4 (68.4–72.4)	39.1 (37.0–41.2)	<0.001	54.3 (53.87–54.73)	26 (25.6–26.4)	<0.001
Somewhat	25.5 (23.6–27.4)	40.7 (38.6–42.8)		37.8 (37.4–38.2)	49.1 (48.7–49.5)	
Greatly affects it	4 (3.2–4.9)	20.2 (18.5–22.0)		7.9 (7.7–8.1)	24.8 (24.4–25.2)	
How concerned are you about your bowel functioning? % (95% CI)						
Not at all	80.6 (78.9–82.3)	43.2 (41.0–45.4)	<0.001	67.1 (66.7–67.5)	33.7 (33.3–34.1)	<0.001
Somewhat	17.1 (15.5–18.7)	49.3 (47.1–51.5)		28.5 (28.1–28.9)	55.8 (55.4–56.2)	
Very concerned	2.4 (1.7–3.1)	7.5 (6.4–8.7)		4.4 (4.2–4.6)	10.5 (10.2–10.8)	

estimates in the 25 other countries are close to the global DGBI prevalence of 40.3% (95%CI, 39.9–40.7).[1] Second, the prevalence of 14 of the 23 Rome IV DGBI did not differ between the UK and other 25 countries pooled, further highlighting the global consistency and burden of DGBI. Of clinical importance, the similarities extended to FD and IBS, the two most recognized and well-known DGBI in clinical practice, which had similar prevalence in the UK to that in the other 25 countries pooled. The UK prevalence in the present study is almost identical to an independent study conducted using the same methodology where UK DGBI prevalence was estimated at 37%, further validating our findings and observations.

Amongst DGBI that were more prevalent in the UK than in the other 25 countries pooled, opioid-induced constipation, chronic nausea and vomiting, and cannabinoid hyperemesis syndrome add further evidence for the role of lifestyle and prescribing practices in influencing DGBI prevalence and variability. Gastrointestinal symptoms such as chronic nausea and vomiting are increasingly recognized as features of cannabis use disorder,[24] and the higher prevalence of cannabinoid hyperemesis in the UK compared with the other 25 countries pooled suggests that there is a need to raise awareness of this amongst acute care physicians in the UK. Recent data from North America suggest that patients with cannabinoid hyperemesis syndrome almost universally have a cannabis use disorder accounting for an increasing burden of emergency department attendances with symptoms related to problematic chronic cannabis use.[25] Based on our findings, it is therefore likely that the UK will inevitably be experiencing increasing direct healthcare costs related to this issue, undoubtedly putting further strain on already stretched healthcare systems, which could escalate if this epidemic is not recognized in the UK. These findings highlight the need for a UK study of the scale of cannabis use and the burden of UK emergency department presentations with cannabis use disorders and related gastrointestinal symptoms.

Similarly, the finding that opioid-induced constipation prevalence was higher in the UK compared with the other 25 countries pooled is concerning, yet not particularly surprising, given the national concerns about an opioid epidemic. Studies over the past decade have highlighted the increasing trend in opioid prescriptions within the UK, and related complications resulting in morbidity and mortality.[26] The current data are also consistent with another study, which has shown that Rome IV opioid-induced constipation prevalence is higher in the UK compared with the USA and Canada.[27] Taken together these data, therefore, highlight the need to raise awareness of the hazards and lack of benefit for opioids for the treatment of chronic noncancer pain. The findings also support an increasing body of evidence within gastroenterology that opioids can be detrimental for chronic pain resulting in hyperalgesia and adverse outcomes.[28] Chronic nausea and vomiting, in addition to their association with cannabis use disorder, are also known gastrointestinal symptoms related to opioid use. These current data will therefore be valuable in raising awareness of opioid-induced bowel dysfunction, which is more common in the UK than the rest of the world. Fortunately, there are several peripherally acting mu-opioid antagonists now available, and recent international evidence-based clinical practice recommendations.[29] Therefore, with early recognition and intervention, leading to a safe reduction and replacement of opioids, effective symptomatic treatment can be achieved for these patients.

Although the exact reasons why four other DGBI including fecal incontinence and proctalgia fugax had a different prevalence in the UK compared with the other 25 countries are unclear, there are several sociodemographic factors identified in this study that may have influenced this variance and will, therefore, be discussed in detail.

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Notably, the UK population surveyed, consisted of a slightly higher proportion of patients in the older age group categories compared with the other 25 countries, which may have contributed to the increased prevalence rate of fecal incontinence, and the lower prevalence of bowel DGBI, which tend to be more prevalent in younger individuals. Interestingly, two "non-IBS" bowel DGBI, namely functional constipation and unspecified functional bowel disorder, were amongst the disorders that were more prevalent in the other 25 countries pooled, when compared with the UK. The clinical importance of these less specific bowel disorders is debatable, and it has recently been suggested that these disorders are part of a less severe spectrum of IBS.[30]

One important factor that may account for some of the variance in bowel disorder prevalence is dietary intake. To the authors' knowledge, this is the first DGBI epidemiology study that has compared food intake between the UK and other countries. The role of dietary intake in contributing to gastrointestinal symptoms is being appreciated increasingly in DGBI.[31] It is therefore interesting that there were differences in food intake of all 10 food groups surveyed between the UK and the rest of the world. British diets consisted of lower rice intake, more regular milk and meat consumption, less frequent pasta consumption, and differences in the frequency of egg, tofu, fish, vegetables/legumes, and fruit consumption. It is therefore plausible that differences in the British diet may have contributed to differences in the prevalence rates of several DGBI compared with the other 25 countries pooled as a group, including the less specific functional bowel disorders. Of interest, our data have shown differences in the pattern of intake of vegetables, legumes, and fruits between the UK and the other 25 countries. These food groups are relevant because they include high fermentable oligo-, di-, monosaccharides, and polyols, which have been shown to induce DGBI symptoms,[32] and evoke differential effects on small and large bowel luminal contents.[33] Moreover, recent data suggest that improvements in abdominal pain in IBS following diets low in fermentable carbohydrates may result from changes in luminal mediators of pain.[34] Diet may, therefore, be directly involved in the pathophysiology and genesis of symptoms, and whilst beyond the scope of the present study, this should be the subject of future international studies. The variance in dietary practices seen in our study is likely to be influenced by religious-, cultural-, and country-specific factors, for example in religions and regions where vegetarianism is important, and in countries where foods such as pasta or rice are staple features.[35] Indeed, it is interesting that several European countries including Germany, Belgium, Holland, and Australia, who have similar cultural backgrounds to the UK, all have very similar bowel DGBI prevalence (Figure S2). For the UK and Spain, this has also been illustrated in a recent DGBI epidemiology study in Gibraltar, which has close cultural, economic, and political influences from both the UK and Spain, using similar methodology to the RFGES. Interestingly, Gibraltar was found to have a very similar prevalence of both IBS and FD to the UK and Spanish data from the RFGES.[36]

Beyond diet, and the lifestyle and opioid-prescribing factors discussed above, there are several other factors, which may have influenced DGBI prevalence between the UK and the other 25 countries pooled. Our data suggest that in the UK, educational status appears to be less important in influencing DGBI prevalence when compared to other countries around the world. Interestingly, DGBI prevalence in both the UK and the 25 countries pooled was lower in those who were married, and as concluded in a recent UK study during the COVID-19 pandemic where unmarried patients had higher burden and severity of IBS,[37] this may relate to social support, which could be explored in future studies. Previous work has suggested a potential influence of religion and area type on the mechanism of DGBI.[38] In contrast to the other 25 countries, our data did not demonstrate an influence of community size on DGBI prevalence in the UK. Interestingly, DGBI prevalence did appear to be influenced by adherence to non-Christian religions or nonspiritual beliefs. It is, however, possible that these observed differences could be influenced by cultural factors independent of religion. For example, a proportion of UK participants having migrated from countries with different non-Christian religious backgrounds may actively maintain dietary and cultural practices akin to their native countries. It is unknown whether this subgroup of individuals within countries may retain DGBI prevalence, which mirrors that of their country of origin. Whilst this could not be explored further within our study, this is an important area for future research especially in countries with multiethnic, multicultural populations such as the UK, where there is a an increasing recognition of the need to prevent racial disparities in order to unify the approach to the diagnosis and treatment of DGBI.[39–42] Finally, whilst beyond the remit of the current study, there is increasing interest in genetic factors, which may be involved in predisposition to DGBI.[43] It is unclear whether genetic variance could account for some of the observed differences in DGBI prevalence between the UK and the other countries in our study. Future global population studies are warranted to determine the effects of genetic variance on DGBI prevalence.

Although IBS prevalence in males and females did not differ between the UK and the other 25 countries pooled, mean IBS symptom severity scores were higher for the UK than in 23 of the other 25 countries, and were significantly higher amongst men in the UK compared with the other 25 countries pooled. This is important given that more severe IBS symptoms can lead to more direct healthcare costs and resistance to treatment.[4,44] The relative uniformity of DGBI prevalence across the UK in our study (ranging from 31.9% in the Southeast of England to 42.1% in the Midlands, Figure 2) build a strong case for the development of cost-effective models of multidisciplinary integrated care throughout the UK, with access to specialist medical, dietetic, and gut–brain behavioral therapies as per the British Society of Gastroenterology guidelines.[10,11]

The reasons for higher IBS severity amongst men in the UK compared with the rest of the world are unclear and merit further study. It has been hypothesized that there are sex-specific differences in the presentation of IBS, but very few studies have assessed this.[45,46] Despite IBS being considered a benign condition, a recent UK study has shown that men with IBS are willing to accept a median 5% risk of death in return for a chance of a permanent cure.[47] The

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median accepted risk of death was higher in men, those with more severe IBS symptoms, depression, and a poorer IBS-related quality of life.[47] Put into context, although our study confirms that the prevalence of IBS in males in the UK is almost three times lower than the prevalence in females, IBS is still common in males, accounting for 1.2% of the UK male population. Moreover, there is some evidence to suggest that men with IBS, who are often underrepresented in randomized controlled trials,[42] may have symptoms that are more treatment-resistant to both medical and gut–brain behavioral interventions.[48,49] Why IBS in males might be more severe specifically in the UK should be studied further, and whether there are any particular cultural factors that make IBS in UK males more difficult to treat. Recent Swedish data have suggested that IBS in men is associated with higher stool frequency, better employment status, less chronic pain, less psychiatric comorbidity, and fewer contacts with the healthcare system compared with women with IBS.[50] A similar study in a UK male IBS population would therefore be valuable to understand whether differences in the way IBS in men is perceived and experienced in the UK could account for the higher severity compared with the rest of the world. Our data also suggest that male patients with IBS should be included in future clinical trials to develop more effective treatments.

Key strengths of this study are the robust online data collection methodology, described in detail elsewhere that minimized data errors.[1] Collection of data using the same methodology across 26 countries using the Rome IV criteria has made in-depth comparison between the UK and other countries achievable with pooled global prevalence rates and across countries. Comparing food consumption by type was useful to provide an insight into the food patterns amongst UK participants and those in the other 25 countries.

As in the original RFGES study,[2] although efforts were made to adjust for organic gastrointestinal diagnoses, participants in the 26 countries were not seen by clinicians or providers prior to inclusion. Hence, undiagnosed organic DGBI mimics may not have been excluded, although their prevalence will be lower than most DGBI, and therefore, the RFGES provides a close approximation of the true prevalence of DGBI in the community. There were several other limitations. First, we have described differences between the UK and the other 25 Internet countries, which follows the approach of Sperber et al.[2] This enables easier comparison with previous work. However, an alternative approach would have been to consider characteristics by country as was undertaken for the forest plots of DGBI using multilevel modeling. The emphasis here, however, is the contrast between the UK and other countries. Second, a similar number of participants from each participating nation were recruited, regardless of the size of the total population of the country being surveyed. This could, potentially, result in relative overrepresentation of smaller countries such as the UK, when comparing the prevalence to larger countries. Third, the RFGES questionnaire on dietary intake was not specific enough to assess links with individual dietary components, so future studies should further assess the role of dietary intake in different countries on the etiopathogenesis of DGBI, and indeed whether any components of the "British diet" is protective against experiencing symptoms of DGBI. Finally, despite the age-matched inclusion criteria in the protocol, UK participants were slightly older than participants in the other 25 countries, and although this may be reflective of the national demographic, we cannot exclude the possibility that this may have influenced the findings.

In conclusion, this study has provided the most detailed epidemiological data on all 22 Rome IV DGBI in the UK, to date, and compared them with pooled data from 25 other countries worldwide. Disorders of gut brain interaction are highly prevalent throughout the UK and are associated with a high burden of healthcare utilization, impaired quality of life, and psychological distress. Most DGBI, including IBS and FD, have similar prevalence in the UK to the rest of the world. Lifestyle factors such as cannabis use, opioid prescribing, British diet, religious, environmental, and cultural factors may account for some of the variance in DGBI prevalence between the UK and other countries. These data highlight the need to develop integrated multidisciplinary services for DGBI throughout the UK, raise awareness amongst the public, and improve training for healthcare providers on their management.

AUTHOR CONTRIBUTIONS

HJ reviewed the literature, performed statistical analysis, data interpretation, and drafted the manuscript. LAH was involved with conceptualization, study design, data interpretation, and reviewed the manuscript. RMW was involved with the study design, statistical analysis and interpretation, and reviewed the manuscript. AA, IA, CJB, MC, ME, PAP, and ACF were involved with conceptualization, study design, and revised the manuscript. FS reviewed the statistical analysis and helped with data presentation and creation of graphical display of DGBI prevalence between countries. PJW, SB, OSP, and ADS were involved with the original data collection for the RFGES, reviewed and approved the study design, and revised the manuscript. DHV was involved with conceptualization, study design, interpretation, helped write and revise the manuscript, and is the guarantor.

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CONFLICT OF INTEREST STATEMENT

None of the authors have any financial disclosures to declare that are relevant to this work.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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