Prevalence of Irritable Bowel Syndrome in Singapore and Its Association with Dietary, Lifestyle, and Environmental Factors

Kewin T H Siah,1,2* Reuben K Wong,1,2 Yiong H Chan,3 Khek Y Ho,1,2 and Kok-Ann Gwee1,2

1Division of Gastroenterology & Hepatology, University Medicine Cluster, National University Hospital, Singapore; 2Department of Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore; and 3Biostatistics Unit, Yong Loo Lin School of Medicine, NUHS, Singapore

Background/Aims
The prevalence of irritable bowel syndrome (IBS) has risen considerably over the past decade in Singapore. We aim to explore the contribution of changes in diet, lifestyle and habits that may contribute to the increased prevalence and development of IBS.

Methods
This is a survey-based cross-sectional population study aimed to gather demographic, socio-economical, lifestyle, dietary, antibiotic usage and other related information. Subjects were adult male or female Singaporeans aged 21 years or above. Association of the factors gathered with the presence or absence of IBS (by Rome III criteria) was assessed using chi-square or Fisher’s exact test.

Variables with a level of statistical significance of 0.1 or less in the univariate analysis were entered into a stepwise logistic regression model.

Results
A total of 297 subjects participated in the study (female 60.3%). Overall, 20.9% subjects fulfilled the Rome III IBS criteria. Univariate analysis showed that IBS was associated with pet ownership, antibiotic usage, late dinner (> 9 PM) and consumption of Western meals, coffee, and bread. The multivariate logistic regression analyses showed that IBS was independently associated with being a pet owner (P = 0.008; OR, 2.5; 95% CI, 1.278-5.037).

Conclusions
The prevalence of IBS was 20.9% using the Rome III criteria in our study. The association between IBS and pet ownership will need further investigation.

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Key Words
Epidemiology; Irritable bowel syndrome; Pets
Introduction

The gradual shift in the epidemiology of gastrointestinal diseases is a phenomenon that is presently witnessed in many parts of Asia; in particular, the prevalence of irritable bowel syndrome (IBS) has risen considerably over the past decade in Singapore.\textsuperscript{1-3} Although the etiology underpinning this disease trend is unclear, the short time span in which these changes have occurred suggests that environmental, rather than genetic, alteration is the crucial determinant.\textsuperscript{4,5} Rapid economic growth and urbanisation have transformed the environment and brought about drastic changes to the socio-economic conditions of inhabitants. The lifestyle for many people has become sedentary, often accompanied by significant dietary changes and/or excesses.\textsuperscript{6-10} All of these factors could have directly or indirectly contributed to the shifts in the epidemiology and prevalence of gastrointestinal diseases. We aim to explore the contribution of changes in diet, lifestyle and habits that may contribute to the increased prevalence and development of IBS.

Materials and Methods

Study Design

This is a survey-based cross-sectional population study aimed to gather demographic, socio-economic, environmental, lifestyle, dietary, and other related information that may help us develop a better understanding of the current prevalence of IBS in Singapore, and factors that could play a crucial role in its etiology and epidemiology.

Subjects

The subjects were adult male or female Singaporeans aged 21 years or above who belonged to any of the 3 major ethnic groups in Singapore: Chinese, Malay, or Indian.

Procedure and Methods

We obtained from the Singapore Department of Statistics a proportional stratified sample of Chinese, Malay, and Indian households that was representative of Singapore's population. Subjects were formally invited to participate in the survey through a letter posted directly to their residential address. Those who responded to our invitation and expressed interest to participate were interviewed individually at their residence.

At the home visits, our trained field investigators further explained the details of the study to the subjects. The subjects were given a chance to ask whatever questions they had. If they were agreeable after having understood the requirements of the participation, they were asked to sign an informed consent form in either English or the subjects' mother tongue (Chinese, Malay, Tamil, or Hindi). Upon obtaining formal informed consent, the investigators proceeded to interview the subjects to gather basic demographic information, as well as their body weight, height, hip, and waist dimensions to determine obesity and fat distribution. Subjects then completed a comprehensive self-administered questionnaire comprising 42 questions on their own, or if necessary, with the help of our field investigators. The investigators also collected 2-3 mL of the subjects’ saliva to determine the presence of Helicobacter pylori infection. All measurements and collection of saliva were carried out by our trained field investigators at the subjects' residence. Principal investigators and team members were available to answer over the phone any queries the field investigators had not been able to address.

Anthropometric Measurements

All anthropometric measurements were taken with the subjects standing in an upright position with light indoor clothing, and without shoes on. Measurement of waist circumferences was taken with the subjects fully exhaled. It was made round the waist at the midpoint between the ribs and iliac crest. Hip circumference measurements were taken around the hips at the greatest horizontal circumference below the iliac crest at the level of the greater trochanter (roughly around the widest part of the hip for women, and round over the tips of the hip bones for men). Digital bathroom scales were used for measuring body weight. For consistency, the scales were calibrated in our laboratory just before the fieldwork. For height, waist and hip measurements, standard measuring tapes were used. All measurements were made in metric units, with weights measured to the nearest 0.1 kg, and height, waist, and hip measurements to the nearest 0.5 cm.

Indices of Obesity and Fat Distribution

For the purpose of determining the levels of obesity and body fat distribution, we used the following indices:

1. Body mass index (BMI), defined as the ratio between weight (kg) and the square of height (m\textsuperscript{2}).
2. Waist circumference, defined as measurement (m) round the waist at the midpoint between the ribs and iliac crest.
3. Waist-hip ratio (WHR), defined as the ratio of the circumference of the waist to that of the hips: waist girth (m)/hip girth (m).
Based on BMI, patients were graded into standard categories established by the World Health Organization with cut-off points modified for Asians. Risk-based cut-off points for waist circumference were gender-specific and as recommended for Asians by the Asian-Pacific Consensus. A waist circumference more than 88 cm in men or more than 80 cm in women indicates central obesity. WHR cut-offs for abdominal adiposity was set at 0.90 and 0.80 in men and women, respectively, as recommended for the Singaporean population.

**Determination of Helicobacter pylori Infection**

The *H. pylori* infection status of the subjects was determined using a commercially available enzyme-linked immunosorbent assay for the detection of the bacteria in biological fluids. Saliva samples collected from the subjects were diluted and pre-incubated with horseradish peroxidase conjugated with anti-human immunoglobulin specific for IgG. The incubation in antibody-coated microwells facilitated the binding of the antigen present in the sample to the corresponding antibody on the surface of the microwells. After the immunological reaction, any unbound conjugate was washed off. A chromogenic substrate was then added to generate a soluble colored solution—the intensity of which was proportional to the concentration of antigen present in the sample. Concentrations were measured at 450/630 nm using a standard enzyme immunoassay microplate reader with the appropriate filters.

**Survey Questionnaire**

In brief, the questionnaire consisted of a short investigator-administered/-assisted section to collect basic demographic and anthropometric information, and a self-administered section comprising a total of 42 questions inquiring about the individual’s socio-economic and cultural background, lifestyle, and dietary information, as well as disease-specific symptoms experienced—specifically, the presence and frequency of validated symptoms diagnostic of IBS.

The 2 parts of the questionnaire comprised the following parameters:

1. Investigator-administered/-assisted section:
   A. Demographic information
   B. Anthropometric information
2. Respondent-administered section:
   A. IBS-related abdominal symptoms
   B. Dyspepsia-related symptoms
   C. Dietary information
   D. Others (socio-economic, cultural and other information)

**Symptom-based Diagnostic Criteria for Diseases**

Abdominal symptoms pertaining to IBS were considered present if the individuals had experienced the symptom(s) in the preceding 6 months at a frequency of at least 3 days a month over 3 months, or approximately 10% of the time.

For symptom-based determination of the presence or absence of disease, the following diagnostic criteria was applied: a subject was classified as having symptomatic IBS if he/she had had symptoms of IBS for at least 3 months, with onset of recurrent abdominal pain or discomfort associated with 2 or more of the following at least 6 months prior to the time of survey: (1) improvement with defecation, (2) onset associated with a change in frequency of stool, and (3) onset associated with a change in form (appearance) of stool.

**Dietary and Antibiotic Usage Information**

Time, location, and size of breakfast, lunch, and dinner were recorded. Dietary intakes were divided, according to frequency, into at least daily or weekly intake of standard meal portions. Subjects with prolonged or repeated antibiotic treatment 2 weeks or longer, or 2 or more courses in a year, were considered as positive antibiotic usage.

**Statistical Methods**

We aimed to study 500 randomly selected subjects. We determined the number of individuals who fulfilled the IBS criteria. The point prevalence of IBS was computed by taking the ratio of the number of disease cases and the total number of the population surveyed. All analyses were performed using IBM SPSS 20.0 (IBM Co, Armonk, NT, USA). Descriptive statistics for the categorical variables were reported as numeric numbers (%). Association of the factors gathered with the presence or absence of IBS was assessed using Chi-square or Fisher’s exact test. Variables with a level of statistical significance of 0.1 or less in the univariate analysis were entered into a stepwise logistic regression model. All P-values were two-sided with the level of significance specified at less than 0.05.

**Results**

A total of 297 subjects (59.4% response rate) participated in the study (female 60.3%) (Table 1). Overall, 62 (20.9%; 95% CI, 56.3–67.5) subjects fulfilled the Rome III IBS criteria. There were 23 (37%) diarrhea predominant IBS, 17 (27.4%) constipation predominant IBS, 11 (17.7%) mixed IBS, and 11 (17.7%) unspecified IBS. Among the subjects whose age ranged between 21 and 30
years old, 27.7% had IBS—the highest prevalence among all age groups. Subjects above 60 years of age had lower prevalence of IBS compared with younger subjects (6.7 vs 22.5%, P = 0.043). The ratio of female IBS to male IBS subjects was 1.2:1. There was no significant difference in gender, race, BMI, WHR, smoking status, education, and housing types.

Univariate analysis showed that IBS was associated with pet ownership, antibiotic usage, late dinner (> 9 PM), and consumption of Western meals, coffee, and bread (Table 2). The multivariate logistic regression analyses showed that IBS was independently associated with being a pet owner (P = 0.008; OR, 2.5; 95% CI, 1.3-5.0) (Table 3).

**Table 1. Characteristics of Non-irritable Bowel Syndrome and Irritable Bowel Syndrome Subjects**

|                      | Non-IBS n (%) | IBS n (%) | Total n (%) |
|----------------------|---------------|-----------|-------------|
| Total                | 235 (79.1)    | 62 (20.9) | 297 (100)   |
| Gender               |               |           |             |
| Male                 | 96 (81.4)     | 22 (18.6) | 118 (39.7)  |
| Female               | 139 (77.7)    | 40 (22.3) | 179 (60.3)  |
| Age groups           |               |           |             |
| Age 21-30            | 47 (72.3)     | 18 (27.7) | 65 (21.9)   |
| Age 31-40            | 61 (78.2)     | 17 (21.8) | 78 (26.3)   |
| Age 41-50            | 56 (78.9)     | 15 (21.1) | 71 (23.9)   |
| Age 51-60            | 43 (81.1)     | 10 (18.9) | 53 (17.8)   |
| Age > 60             | 28 (93.3)     | 2 (6.7)   | 30 (10.1)   |
| Race                 |               |           |             |
| Chinese              | 165 (77.8)    | 47 (22.2) | 212 (71.4)  |
| Malay                | 25 (80.6)     | 6 (19.4)  | 31 (10.4)   |
| Indian               | 30 (93.8)     | 2 (6.3)   | 32 (10.8)   |
| Others               | 15 (79.1)     | 7 (31.8)  | 22 (7.4)    |
| BMI                  |               |           |             |
| < 18.5               | 16 (69.6)     | 7 (30.4)  | 23 (7.7)    |
| 18.5 to 24.9         | 145 (80.1)    | 36 (19.9) | 181 (60.9)  |
| ≥ 25.0               | 74 (79.6)     | 19 (20.4) | 93 (31.3)   |
| Waist-hip-ratio      |               |           |             |
| < 0.8                | 40 (76.9)     | 12 (23.1) | 52 (17.5)   |
| 0.8 to 0.89          | 108 (77.1)    | 32 (22.9) | 140 (47.1)  |
| ≥ 0.9                | 87 (82.9)     | 18 (17.1) | 105 (35.4)  |
| Smokers              | 37 (80.4)     | 9 (19.6)  | 46 (15.5)   |
| H. Pylori (+)        | 33 (82.5)     | 7 (17.5)  | 40 (13.4)   |

IBS, irritable bowel syndrome; BMI, body mass index; H. pylori, Helicobacter pylori.

**Table 2. Univariate Analysis of Risk of Irritable Bowel Syndrome Showing Results with P-value < 0.1**

|                      | OR (95% CI) | P-value |
|----------------------|-------------|---------|
| Pet ownership (ever) | 2.3 (1.3-4.2) | 0.005 |
| Non-breakfast taker  | 2.7 (1.3-5.8) | 0.008 |
| Western meal (> once/wk) | 2.1 (1.2-3.6) | 0.012 |
| Non-coffee drinker   | 2.0 (1.1-3.5) | 0.018 |
| Bread (daily intake) | 1.9 (1.0-3.6) | 0.035 |
| Age < 60             | 4.1 (1.0-17.5) | 0.043 |
| Antibiotic usage     | 1.8 (1.0-3.1) | 0.046 |
| Rice (daily intake)  | 2.0 (1.0-4.0) | 0.053 |
| Oily food (daily intake) | 2.0 (1.0-3.9) | 0.053 |
| Single               | 1.8 (1.0-3.2) | 0.067 |

**Table 3. Multivariate Analysis of Risk of Irritable Bowel Syndrome**

|                      | OR (95% CI) | P-value |
|----------------------|-------------|---------|
| Pet ownership (ever) | 2.5 (1.3-5.0) | 0.008 |
| Non-breakfast taker  | 2.3 (0.9-2.6) | 0.075 |
| Antibiotic usage     | 1.6 (0.8-3.1) | 0.135 |
| Non-coffee drinker   | 1.5 (0.8-2.8) | 0.252 |
| Western meal (> once/wk) | 1.5 (0.7-2.9) | 0.277 |
| Age < 60             | 2.3 (0.4-10.8) | 0.307 |

**Table 4. Irritable Bowel Syndrome Subtypes and Pet Ownership**

| Subtype             | Total n (%) |
|---------------------|-------------|
| IBS-C               | 10 (27.0)   |
| IBS-D               | 13 (35.1)   |
| IBS-A               | 7 (18.9)    |
| IBS-U               | 7 (18.9)    |
| Total               | 37 (100)    | 25 |

IBS, irritable bowel syndrome; IBS-C, constipation predominant IBS; IBS-D, diarrhea predominant IBS; IBS-A, alternating IBS; IBS-U, unspecified IBS.

Pet Owners

There were 78 pet owners. Thirty-one owners had furry animals such as cats, dogs, and hamsters; 8 had birds, and 21 had other pets such as tortoises and fish, etc. Eighteen subjects did not specify the type of pet(s) they had. Twenty-five (32.1%) pet owners had IBS. Bloating was the most bothersome symptom for 30.8% of pet owners, followed by abdominal discomfort. Majority of the pet owners with IBS suffered from diarrhea-predominant subtypes (40%) but there was no statistical difference between IBS subtypes (Table 4).

Discussion

The prevalence of IBS was 20.9% using the Rome III criteria...
in our study. IBS prevalence in Singapore was found to be 2.3% in 1998 in a study by Ho et al using the Manning criteria. In 2004, Gwee et al reported a prevalence of 8.6% in another community study using the Rome II criteria. The prevalence of IBS Rome II criteria in Asian countries were well summarized in the review by Gwee et al. By Rome II criteria, Taiwan had the highest prevalence for IBS, 22.1% among Asian countries. However, there were limited published data on the prevalence of Rome III IBS in Asia. The reported prevalence of Rome III IBS was 13.1% in Japan, 10.9% in Malaysia (Malay population) and 9.0% in Korea. The higher prevalence of IBS in Singapore compared to these countries may represent the economic success and stability achieved by Singapore for the last decades. Gwee et al also reported a trend of higher prevalence of IBS in affluent city states like Hong Kong and Taipei. The association of IBS with higher socio-economic status was also reported in the West.

Our study shows an association between IBS and pet ownership. However, in this study the duration and period of exposure to pets was not studied. This study included all past and present pet owners. This finding is consistent with what was discovered by the Talley’s group. In a study examining childhood environmental risk (less than 5 years old) and development of IBS and functional dyspepsia in Australia by Koloski et al, they found that pet ownership was an important risk factor for IBS and functional dyspepsia in later adult life. Interestingly, they differentiated pet categories according to their diet and showed that herbivore pets such as horses and birds were the main culprits. Koloski et al thought that shorter duration of breast feeding, caesarean section, and exposure to pets may increase exposure to endotoxins and alter the gut microbiota which favor the development of IBS by tilting the balance of cytokines profile towards a T helper 2 response.

Animals like dogs and horses have been involved in animal-assisted therapy in multiple chronic conditions. We often see dogs assisting people with various disabilities, and animals can also help in reduction of anxiety and depression, improvement in mood and development of social skills. Pet ownership could be a compensatory mechanism in patients suffering from IBS, perhaps due to the beneficial effects of pet-companionship on mood disorders, depression, and anxiety. Although we did not collect information on mood or psychological profiles in our subjects, anxiety, and mood disorders have been found to be more prevalent among patients suffering from IBS.

On the other hand, pet ownership is inevitably associated with an increased exposure to animal dander. Animal dander are particles sloughed from the animal skin. Allergens from cats and dogs, such as Fel d1 and Can f1, can remain airborne for prolonged periods of time and attach themselves to clothing and hair. The prevalence of human allergy to pet dander has increased, due to rising public and domestic environmental exposure to pet allergens. Human diseases associated with sensitisation to these allergens include allergic rhinitis, allergic asthma, and atopic dermatitis. There have been several reports of increased prevalence of IBS among atopic patients, especially patients with asthma. In a large primary care study of general practitioner diagnosed IBS, the odds ratio for IBS among asthma patients was 2-fold that of controls. Tobin et al reported increased mucosal mast cells in a group of IBS patients with concurrent atopic disease. Another study showed that mast cell and eosinophil concentrations in duodenal biopsies increased during the pollen season. This association has been termed “atopic IBS”, which may represent a distinct subset of IBS. Atopic patients were also shown to have increased intestinal permeability and density of IgE-bearing mast cells. Sensitisation to food allergens, which were reported by patients to induce their gastrointestinal symptoms, was not shown (both via measurement of serum-specific food IgE and skin prick test).

However, the role of aeroallergens in causing gastrointestinal symptoms has not been fully explored. A study by Vinimus-Nebot et al showed that atopic IBS patients had more severe disease and diarrhea-predominant symptoms. In the same study, it was shown that IBS patients had higher sensitivity to aeroallergens compared with controls. Interestingly, Hunskaar et al showed that in a cohort of post-Giardia infection patients, non-atopic patients were found to have increased risk of IBS after Giardia infection but the effect was not seen in atopic patients.

Our study did not find a significant dietary or obesity marker for development of IBS. There were mixed results regarding the association of IBS and obesity. There were studies that found higher IBS prevalence with increased BMI and waist-circumference and visceral adipose tissue. Other authors cautioned regarding selection of study patients and need of a standardized assessment of obesity. Larger sample sizes may be needed to elucidate whether there was an association between BMI and IBS. Secondly, a better and more detailed dietary questionnaire with a recorded temporal relationship with symptoms should be utilized in future studies to investigate the effect of diet on IBS.

A limitation of the present study is the relative small number of participants, though the racial and weight distribution mirrored the national pattern. There is also a lack of relevant data regarding pet ownership, allergy status and psychological profiles. The relationship of pet ownership and IBS, though interesting, will need further...
in-depth investigation due to its potential implication for prevention and treatment of IBS. In future, studies should accurately document the type of pets and chronology of pet owning meticulously to produce any meaningful results. It is also important to include the allergic status and psychological profile to rule out possible confounders.

In conclusion, the prevalence of IBS was 20.9% using the Rome III criteria in our study. Our study showed that there was an association between IBS and pet ownership. This new association is interesting because it may unfold the hitherto mystery relationship between IBS and atopic diseases, especially the high prevalence of IBS seen in asthmatic patients. Whether aerollergens, such as animal dander, house dust mites or pollen, play any role in the pathophysiology of IBS will need to be explored in future studies.

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Author contributions: Kewin T H Siah: planning and/or conducting the study, collecting and/or interpreting data, and/or drafting the manuscript; Reuben K Wong and Yiong H Chan: interpreting data, drafting the article or revising it critically for important intellectual content; and Khek Y Ho and Kok-Ann Gwee: planning and/or conducting the study, final approval of the version to be published.

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