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Investigation and Analysis of the Relationship Between Gastric Disorders and Gluten Disorders Among Residents of Yushe County, Shanxi.

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Abstract: Celiac disease, wheat and gluten allergies, and non-celiac gluten sensitivity are the three types of conditions belonging to gluten-related disorders. While already a popularly known issue in developed countries, both medical professionals and the general populace in China lack basic knowledge of gluten-related disorders. However, previous studies have found that gluten-related disorders are possibly pervasive in China. This study targets the rural areas of Yushe, Shanxi, where wheat-based foods are the main staple. It confirms the relationship between gastric disease occurrences and nut-and-grain allergies through a logistic regression model, with wheat and gluten being the most dominant foods in the local diet under this category. Therefore, gluten disorders may actually have the greatest impact on gastric diseases in villagers. Well-designed prospective studies are needed to establish the causality between gluten-related disorder and gastric disease.

Keywords: Gluten-Related Disorder; Wheat and Gluten Allergy; Gastric Disease; China

1. Introduction

1.1 Research Background

A county in northeastern China, Yushe, Shanxi, has a population of around 35 million, with an area of about 60,500 square miles, of which 80% are mountains and hills. The area is located inland in the mid-latitude zone and has a temperate continental monsoon climate (Shanxi Provincial Bureau of Statistics 2023). From various noodles to buns and dumplings, foods made from wheat flour constitutes a major part of the local diet (Wank 2015).

During on-site visits, a high prevalence of gastric diseases was found among the villagers living in the area. 8 out of 10 households have at least one member who suffers from chronic stomachache, bloating, or nausea. Moreover, people die of stomach cancer every year. Based on their symptoms and dietary habits, we suspect that gluten-related disorders coupled with continuous gluten intake could be associated with their gastric diseases.

1.2 Literature Review

Gluten-related disorders, including celiac disease, wheat and gluten allergies, and non-celiac gluten sensitivity, are emerging as a progressively prevalent issue, what once believed to be relatively rare is now estimated to affect nearly 10% of the population (Sapone et al. 2012). It incurs a range of symptoms, with digestive symptoms being the most prominent, and if left uncured, could even result in cancer in the most extreme of cases (Catassi, Italo Bearzi, and Holmes 2005).

While gluten-related disorders have garnered significant attention in developed nations such as the United States, Canada, and various European countries, there exists a notable dearth of knowledge and awareness regarding these conditions among both medical professionals and the general populace in China (NPD Group 2013).

Small sample studies find that amongst Chinese adults and children with chronic diarrhea, the presence of celiac disease-related antibodies ranges from 1.77% to 12% (Wang et al. 2011). Examining 1,952 patients with severe allergic reactions, another study shows that wheat is the primary food factor causing anaphylactic shock in Chinese people (Jiang et al. 2016). Furthermore, there is a noteworthy prevalence of irritable bowel syndrome in China, ranging from 4.4% to 11.8% (Zhang et al. 2014). Given its frequent misdiagnosis alongside gluten sensitivity, and considering wheat's status as China's second largest staple, it is plausible that China may have a substantial population

with gluten sensitivity (Rubio–Tapia et al. 2009).

1.3 Significance

This study contributes to the literature in two ways. First, there are currently close to none existing academic papers on gluten-related disorders in China, and none looks at the correlation between gastric disease and gluten-related disorders. This paper therefore presents new findings, offering unique insight into gluten-related disorders in China.

Secondly, by looking at the correlation between the prevalence of gluten-related disorders and incidence of gastric disease, I can propose gluten-related disorders as a possible cause for the villagers' gastric diseases if the variables are strongly correlated or rule out the possibility if the correlation is low. This will provide a foundation upon which studies on the causality between gluten-related disorders and gastric disease can be conducted in further depth.

The results of this investigation will bring to light the often-overlooked pervasiveness of gluten-related disorders in China, provide a basis for further research, and serve as a reference for policymakers pertaining public health. For these reasons, this investigation is worth conducting.

2. Objects and Methods

2.1 Questionnaire

In July 2023, a random sample of 150 survey respondents was selected from the villages of Nanhedi and Xihe, both situated within Yushe County. Yushe County is situated within Jinzhong City, Shanxi Province, which was chosen as the study's research site. This investigation distributed a total of 150 questionnaires, of which 127 were collected, with 119 valid responses, resulting in a 93.7% response rate.

The investigation was conducted with responses obtained through random sampling of the self-designed questionnaire "Shanxi Gastric Disease and Chronic Food Allergy Survey Questionnaire". The survey consisted of 15 questions, comprising 11 single-choice and 4 multiple-choice questions. These questions encompassed various aspects including respondents' demographic information (gender and age), dietary habits, gastric disease conditions (symptoms, onset time, severity), and their level of awareness regarding food allergies. The collected survey data was inputted into Microsoft Forms and subsequently verified. Descriptive analysis of the questionnaire was then carried out using Microsoft Excel.

2.2 Food-Specific IgG Antibody Assessment

A test was conducted on the total immunoglobulin G (IgG) antibodies of the villagers using finger-tip blood samples from 37 random villagers at the Nanhedi and Xihe villages. Proteins from 22 different food items, including wheat and gluten, were used in the test, revealing the test subjects' immune response towards the foods. In other words, this test tests for non-celiac wheat and gluten sensitivity amongst the villagers at Yushe County, Shanxi Province. We obtained finger-tip blood samples from villagers, utilizing a testing kit, and forwarded them to a Shanghai-based laboratory within the CTI Testing Group for analysis.

2.3 On-site Interviews

On-site interviews were also conducted, in which we communicated directly with villagers to understand their dietary habits, symptoms, and coping attitudes towards gastric disease as well as reasons behind them.

3. Results and Discussion

3.1 Gastric Disease

Of the respondents surveyed, 49 are male (41%), 70 are female (59%); the number of people with ages 20 or below, 21 to 40, 41 to 60,

and 61 or above are 0, 6, 31, and 82 respectively; most of the respondents are at ages 61 or above, with 42 (35%) who is from 61 to 70, and 31 (26%) who is from 71 to 80.

Results show that 84 (71%) of the resident villagers of the two villages studied have experienced chronic gastric discomfort. Among them, 1 person (1%) finds their symptoms neglectable, 41 people (49%) rated them as mild, 17 (20%) as moderate, 22 (26%) as somewhat severe, and 3 (4%) as severe.

According to those surveyed, 31 exhibit bloating, 53 experience stomachache, 37 show nausea, 3 suffers from diarrhea, 51 display indigestion, 10 report constipation, and 23 exhibit vomiting. It can be seen that stomachache and indigestion are notably common among the symptoms.

3.2 Gluten Disorder

Apart from symptoms of gastric disease, results from the survey also revealed that the majority of the villagers (62%) have experienced headache and dizziness, a common symptom of wheat and gluten sensitivity. In addition, 2 have experienced rhinitis and regular sneezes, 2 have experienced itchiness and rashes.

From the food-specific IgG antibody assessment, a combined total of 14 out of the 37 (38%) tested villagers are found to be sensitive to wheat and gluten, with 10 sensitive to wheat and 4 sensitive specifically to gluten. Of those with wheat sensitivity, 8 are mild and 2 are moderate, and of those with gluten sensitivity, 2 are mild and 2 are moderate.

Among the 14 people with wheat and gluten sensitivity, 14 (100%) have reported to having chronic gastric symptoms. The number of people experiencing indigestion, headache/dizziness, bloating, stomachache, nausea, and vomiting are 8, 8, 3, 5, 3, and 3 respectively.

3.3 Relationship Between Gastric Disease and Food Allergy

In order to further analyze whether gastric diseases in villagers are related to food allergies, this study used 37 villagers who underwent antibody testing as research samples to establish a logistic regression model for validation. Logistic regression analysis requires a sample size of 10 times the number of independent variables. In this model, the independent variable is various types of food allergies (such as nut and grain food allergies, egg milk food allergies, seafood food allergies, etc.), and the dependent variable is whether the residents have gastric diseases.

Firstly, assign the dependent variable Y of logistic regression to 0 and 1, where 0 represents no symptoms of gastric disease and 1 represents symptoms of gastric disease.

The independent variables X of logistic regression are also assigned values of 0 and 1, where 0 indicates that villagers are not allergic to this type of food and 1 indicates that villagers are allergic to this type of food.

We establish a logistic regression model as follows:

$$Y = a + b1X1 + b2X2 + \cdots + bnXn$$

Firstly, describe the distribution of dependent variables in the sample (Table 1) : 70.27% of villagers suffer from gastric diseases, and 29.73% of villagers have no symptoms of gastric diseases.

The model evaluation results(Table 2) show that the Likelihood-ratio chi-square test results of the model show a significance P-value of 0.011 * * , showing significance at the horizontal level, rejecting the original hypothesis, thus the model is effective.

Table 1 Distribution of dependent variables

Y	Option	Frequency	percentage (%)
Suffering from gastric diseases	Yes	26	70.27
	No	11	29.73
	Total	37	100

Table 2 Model evaluation results

Likelihood-ratio chi-square	P	AIC	BIC
28.457	0.011**	42.457	53.733

Note: * * *, * *, * represent significance levels of 1%, 5%, and 10%, respectively

The results of binary logistic regression show that:

The significance P-value of Nuts & grains is 0.060 *, showing significant significance at the level. Therefore, nuts and grains allergies will have a significant impact on patients with gastric diseases.

The significance P value of other food all more than 0.1, which is not significant at the level, so other food will not have a significant impact on patients with gastric diseases.

Table 3 Logistic regression results

Experimental group=is		Error	Wald	P	OR	95% confidence interval of OR value	
						upper limit	lower limit
	-0.479	0.522	0.843	0.359	0.619	0.222	1.723
Nuts & grains	2.546	1.356	3.526	0.060*	12.751	0.894	181.787
Meat	23.518	82263.125	0	1.000	16356527437.254	0	-
Seafood	-0.29	292547.699	0	1.000	0.749	0	-
Egg & milk	23.599	45276.976	0	1.000	17744477233.402	0	-
Vegetable	-1.152	1.891	0.371	0.542	0.316	0.008	12.865
Fruit	1.641	1.689	0.945	0.331	5.162	0.189	141.307
Dependent variable: Suffering from gastric disease							

Note: * * *, * *, * represent significance levels of 1%, 5%, and 10%, respectively

In summary, there is a significant correlation between gastric diseases and chronic food allergies among residents in Yushe County, Shanxi Province. Especially, allergies to nuts and grains have a real and significant impact on residents suffering from gastric diseases (p=0.060 *). Among them, gluten food such as wheat, as a staple food in the daily lives of local residents, cannot be underestimated in their impact on gastric diseases.

4. Cause Analysis

4.1 Dietary Habits

Residents of Yushe County, Shanxi Province have been eating foods made from wheat flour for generations. The iconic Daoxiaomian, Youmian Jin, and Shuijiao are just examples. According to “Shanxi Gastric Disease and Chronic Food Allergy Survey Questionnaire”, 107 out of 119 people eat millet gruel, 108 eat various noodles or other food made from wheat flour, and 89 eat buns every day, showing that wheat flour constitutes a major part of people’s diet at Yushe. The reasons behind such a diet encompass a wide spectrum: traditional, geographic, and economic factors.

The people in Shanxi have a recorded two thousand years of history of wheat foods. In fact, it is known as “The Root of World Noodles”, with origins tracing back to the dawn of the Ancient Chinese civilization (Tang et al. 2018). With generations of exposure and consumption of wheat foods, people at Shanxi have become accustomed to and dependent on eating wheat foods.

As an area located in northeastern China, Shanxi Province mainly produces wheat, maize etc., as staple crops, while economic crops include ginseng, hemp, apples, walnuts, persimmons, peppers, cotton, soybeans, ferns, etc. (Shanxi Provincial Bureau of Statistics 2023).

Due to its location, Shanxi has a more arid climate compared to southern provinces, with an average yearly rainfall of about 508.8 mm (Shanxi Provincial Bureau of Statistics 2023). In contrast, the province with the highest rice output, Sichuan, has an average yearly rainfall of 1070.5 mm, which is more than double the rainfall at Shanxi (The People’s Government of Sichuan Province 2020). As a result, the average rice output for Sichuan has exceeded 14 million tons since 2013 (Xu, Wu, and Ge 2018), while only slightly over 2000 tons for Shanxi (Shanxi

Provincial Bureau of Statistics 2023).

Moreover, as 80% of the land in Shanxi are mountains and hills (Shanxi Provincial Bureau of Statistics 2023), transportation is difficult, low in efficiency, and costly. Considering these factors, therefore, the price for rice in Shanxi is notably higher than that of wheat flour, with an average of 6.43 RMB per kilogram and 5.06 RMB per kilogram for rice and wheat respectively (Shanxi Economic Daily 2023). Thus, the economically poor villagers would opt for wheat and not its immediate substitute rice, resulting in a diet comprised mainly of wheat flour.

4.2 Wheat Foods as a Main Staple

From 3.3 it can be observed that the significance P-value for the Nuts & grains category is 0.060*, while it is 1.000, 1.000, 0.542, and 0.331 for Meat, Seafood, Egg & milk, Vegetable, and Fruit respectively. This indicates that while there is a high correlation between gastric disease and chronic food allergies among residents in the Yushe County, allergies to nuts and grains specifically have a real and significant impact.

Wheat foods are the main staple of Shanxi, and it is a major part of the local diet. Of the 119 survey samples collected, 108 (over 90%) include wheat-based foods in their thrice-daily meals. This makes wheat foods far more common than corn, the second most consumed grain under the category, which only 68 (57%) of the respondents reported eating every day. Therefore, the effect of wheat and gluten allergies on the villagers' gastric symptoms may in fact be the most significant.

A possible explanation for the results obtained in 3.3 is the leaky gut syndrome, in which a weakening of the intestinal walls allows partially digested food to enter the bloodstream. consistent ingestion of high quantities of gluten protein elicits inflammation, worsening leaky gut and thus causing autoimmune responses on a wider range of food molecules, making villagers allergic to a variety of other foods like soy, potatoes, pineapples, milk, edamame, spinach etc. (Giacomo Caio et al. 2020). The fact that these foods are rarely, if ever consumed by residents at the remote villagers of Yushe, Shanxi, coupled with the sheer diversity of the allergens makes the first notion reasonable.

4.3 Cognitive Level

While it is undeniable that education overall has become more accessible in recent years, people at Yushe still lacked the level of cognition that allows them to know the concept of gluten and associated gluten disorders.

From survey results, it can be seen that 90 out of 119 respondents (76%) were not aware of food intolerance, and of those 29 (24%) who knew of some cases of food intolerance, none knew about the possibility of being intolerant to wheat or gluten. At the same time, 0 reported to knowing many people with food intolerance, demonstrating that food intolerance alone mostly remains an unknown concept, not to mention wheat and gluten intolerance.

Responses to the survey reveals that 33 (35%) people believe that their gastric symptoms are caused by stomach cold, 23 (24%) people think of eating spoiled food, and only 3 (3%) believe the reason to be food intolerance. These responses show that people still tend to resort to traditional and stereotypical causes for gastric disease.

However, 35 (37%) people have noted that they feel like "other" factors have contributed to their gastric symptoms. This might imply that some people have already begun to have the notion that their gastric symptoms cannot simply be explained by stomach cold and eating spoiled food.

4.4 Coping Attitude

Interviews revealed that in response to their gastric symptoms, villagers often do not visit the hospital, which, according to them, is due to a lack of financial ability. Villagers are not clear on the coverage which their medical insurance provides, and when they consult medical staff at local hospitals, the staff would respond saying that they do not know as well. Another reason for not visiting the hospital is that when they were younger, they believed their symptoms to be neglectable and nothing major.

However, as time passes by, symptoms intensify in severity, and diseases develop further. When the symptoms become unbearable, they would take their last resort: to visit the hospital. Often times diseases have developed to a point where it is incurable. At this point, simi-

larly, villagers will refuse to receive treatment, as the expenses are entirely unaffordable.

Many tragedies resulted, including a mother telling me of her daughter who passed away at 45 years old because of stomach cancer, which is a severe extreme of gastric diseases. According to the villagers, three brothers also passed out one by one from stomach cancer, and these are mere examples of the great many who died from the disease.

To sum up, their lack of financial ability resulted in their reluctance in visiting the hospital, which caused a passive coping attitude, which caused diseases and conditions to worsen. In addition, the medical insurance system is not entirely mature, and its coverage not sufficiently transparent, so that villagers would often spend more money at hospitals than what is affordable.

5. Conclusion and Suggestions

The study was designed to explore the relationship between gastric disease and chronic food allergies. The logistic regression model found that there was a high positive correlation between chronic food allergies and gastric disease occurrences, with nut-and-grain allergies being the most significant. Due to the dominance of gluten foods in the local diet, wheat and gluten allergy, a type of gluten disorder, may actually have the greatest impact on gastric diseases in villagers. Moreover, this study speculates that gluten disorders may be the root cause of other food allergies, but the accuracy of this speculation needs to be further confirmed in the future.

Based on results of this study, it is suggested that there should be more advertisement and public education on gluten disorders, and accessibility for gluten allergy tests should be promoted. Improvement in these two aspects could potentially enhance public health and well-being, increasing overall social welfare.

Future studies on the topic could focus on the causality between gluten disorder and gastric disease, as this study merely looks at the correlation between the variables.

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