The impact of dietary fiber on mental health: A population-based survey

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# Background

Mental health disorders, such as anxiety, are a major public health concern with significant impacts on individuals and society (1). Anxiety can be defined by the emotions of worry, fear, and unease, and it can be induced by multiple causes, including genetics, life experiences, and the environment. Effective treatments for anxiety, such as cognitive-behavioral therapy and medication, are available, but there is a need for additional treatments that are more accessible, cost-effective, and have fewer side effects (1).

The bidirectional communication between the gut and the brain is referred to as the gut-brain axis (2, 3). This communication is also influenced by the gut microbiome, which is a collection of microorganisms that live in the gut. Research has shown that the gut microbiome can influence the brain and behavior, and that changes in the gut microbiome can affect mental health (2). Conversely, mental health conditions, such as depression and anxiety, can also affect the gut microbiome (3).

Fiber is a type of carbohydrate that is found in plant-based foods, such as fruits, vegetables, legumes, and whole grains (4). Fiber has several documented health benefits, including improving digestive health, lowering cholesterol levels, and helping to regulate blood sugar levels (5). Fiber also plays a crucial role in the health of the gut microbiome (2). Additionally, high-fiber foods tend to be rich in a variety of nutrients that are important for overall health and well-being, including vitamins, minerals, and antioxidants, which may also contribute to improved mental health (4). The average fiber intake in Sweden for adults is estimated to be 20g/day, which is also lower than the recommended intake (6).

There is some evidence to support the hypothesis that dietary factors, notably the intake of dietary fiber, may be connected with one's mental health (7–10). It is not entirely understood how dietary fiber may contribute to improved mental health; nevertheless, it is suspected that dietary fiber may assist in controlling the synthesis of certain neurotransmitters, such as serotonin, which are involved in mood regulation (3).

# Justification

Mental health disorders, such as depression and anxiety, are common and often debilitating conditions that can significantly impact a person's quality of life (1). These disorders can also have serious consequences for physical health as well as social and economic well-being. The extrinsic risk for the participants is minimal; the participants are informed of all known risks and study relevant information through the use of an invitation letter and consent form.

Conducting research on mental health disorders can help to improve our understanding of these conditions and how they can be effectively treated and managed. This can ultimately lead to the development of more effective and personalized treatments for people with mental health disorders, which can improve quality of life and reduce the burden on society.

# Aim

The aim of this study is to explore the relationship between general anxiety and dietary fiber intake to determine whether increasing dietary fiber intake may be a useful strategy for improving mental health and reducing the risk of anxiety.

# Research question

What role does low dietary fiber intake (<20g/d) have in the prevalence of general anxiety among Swedish adults (20–64 years) versus those with high dietary fiber intake (>20g/d)?

# Methodology

## Study design

The proposed study design is a cross-sectional study in which data on exposures (fiber intake) and outcomes (general anxiety symptoms) will be collected at the same point in time.

## Sampling strategy

The proposed study aims to examine the relationship between fiber intake and mental health in the general population of Swedish adults between the ages of 20 and 64, which is our *target population*. The *sample frame* for this study would be the Register of Total Population (RTB) from Statistics Sweden (SCB) (11). This register includes information on approximately 99% of the Swedish population, including names and postal addresses. This sampling frame would be used to draw a sample of individuals from the target population for the study.

It is important to use a sampling frame that is representative of the target population in order to ensure that the findings of the study are generalizable to the larger population. By using the RTB as the sampling frame, we can be confident that the sample is representative of the target population and that the results of the study can be generalized to the larger population of Swedish adults between the ages of 20–64.

In order to ensure that our sample is representative of the target population, we will use *probability sampling*, specifically *systematic random sampling*. Probability sampling is a method of sampling that uses randomization to select individuals from the target population, and it allows us to make statistical inferences from our sample to the general population. This provides greater external validity for our results, as we can be confident that the sample is representative of the larger population. Systematic random sampling is a specific type of probability sampling in which individuals are selected from the sampling frame at regular intervals. This helps reduce the chance of bias in the sampling process.

In order to collect data from the sample participants, we will use a self-administered survey that will be mailed to them along with an invitation letter, a consent form, and a prepaid return envelope. The survey will be conducted using a postal service, and each sampling unit (i.e., individual participant) will be contacted by post. By using a self-administered survey and a postal service, we can minimize the potential for bias that may be introduced through face-to-face interactions. This will help to ensure the reliability and validity of the data collected.

## Sample size

Our proposed null hypothesis is that there is no difference between proportions of having anxiety between low and high fiber intake. We must also estimate the effect size and variability. The United States Census Bureau assessed the prevalence of anxiety symptoms in 2019-2020, finding a 30% prevalence (12). Furthermore, a cross-sectional study of Iranian adults found that those with the highest total dietary fiber intake had a lower incidence of anxiety, with an odds ratio (OR) of 0.50 (95% CI: 0.31, 0.80) (13).

The two-sided level of statistical significance (α) is set to 0.05, and power is set to 0.8. *P1* represents the proportion of anxiety with low fiber intake, *P2* represents the expected proportion of anxiety with high fiber intake, is the pooled proportion, *q1* and *q2* are the group proportions (high vs low) and assumes equal groups (i.e., 50/50), *Z1-α* and *Z1-β* are the standard normal deviates for 1-α and 1-β (i.e., power) respectively, is equal to ceiling function to *n*:

This yields an estimated total sample size of 372.

We may also need to consider design effects, however, the design effect for systematic random sampling may be close to 1, meaning that it has a minimal impact on the precision of the estimate (14). Another factor that affects sample size is response rate, which may require a larger sample size for low rates (14). Previous research on mental health in Sweden suggests a 50% response rate (15). To account for the expected response rate of 50%, the sample size is multiplied by factor of two to get a final sample size of 744 individuals.

It is important to remember that these calculations are based on a number of assumptions and estimates, and the actual sample size may be different depending on other factors.

## Instrument design

The overall design of the questionnaire was modeled using the *Total Design Survey* method, which helped focus on different design choices in response type for each question (16, 17). This included sectioning with headers, colored bars, and varying font sizes. The questions were crafted to be of different types and scales, such as categorical and 5-point scales. As well as questions of different types such as ratings, frequencies, proportions, and multiple choice. The questionnaire was divided into three sections: dietary intake, anxiety symptoms, and demographics.

The first section with questions regarding dietary intake was to some degree adapted from the *National Cancer Institute’s Diet History Questionnaire III* (DHQ III), in which the frequency of consumption of fresh fruit and raw and cooked vegetables is measured (18). As well, questions measuring probiotic intake and supplementation as confounding factors were added, as these can change the behavior of the gut microbes (2). Assessment criteria adapted for dietary habits used in nutrition epidemiology were also used (19, 20).

The second section about anxiety symptoms was adapted from validated questionnaires, such as the *Hamilton Anxiety Scale* and *Anxiety Symptoms Questionnaire* (ASQ) (21, 22). A multi-choice response regarding a range of symptoms associated with anxiety was also added.

The last section is intended to measure demographic characteristics, such as age and gender. However, questions regarding gender or sex can be sensitive to some, and thus it is important for researchers to uphold those ethical standards that do not misrepresent people’s gender due to the common practice of the binary approach (e.g., female or male) (23). Our initial approach was to add a four-choice scale regarding gender: female, male, non-binary, other / prefer not to say (23).

## Pilot testing

A small pilot study was conducted in order to test the feasibility and effectiveness of the survey instrument that was developed to examine the relationship between fiber intake and general anxiety. A sample of five participants was selected for the pilot study, which also accepted to participate, consisting of friends and family members who were representative of the target population. The survey was administered to the participants in paper form, along with an invitation letter and an informed consent form.

The data and feedback collected from the pilot study were used to make any necessary modifications to the survey instrument. For example, based on the feedback received, definitions were added to certain terms, e.g., “berries” to “fresh fruit”. A question regarding self-reported perceptions of fiber intake was added. One participant reported that the question regarding age (which used the last birthday concept) was strange and convoluted. However, it was kept, as literature has shown that this method tends to result in higher response rates (16, 24). The gender question was also reformulated to be more inclusive and avoid the "othering" effect of closed-ended options like "other" and "prefer not to say" (25). Finally, information was added to the introductory paragraph to clarify the difficulty of answering some questions.

Overall, the pilot study provided valuable insights into the strengths and weaknesses of the survey instrument and allowed us to improve and ensure its reliability and validity.

## Statistical analysis

Descriptive statistics would be used to summarize the characteristics of the sample, such as the mean, median, and standard deviation of the fiber intake scores and anxiety scores, which could further be stratified into age categories. A histogram of the frequency distribution would be useful for exploratory visualization to check for normal distributions. A correlation analysis would be used to examine the strength and direction of the association between fiber intake and anxiety scores. Finally, a chi-square test would be used to compare proportions of anxiety and fiber intake. All statistical analyses will be conducted using the statistical software STATA.

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