Association of socioeconomic condition with serum uric acid, urea & creatinine profile of women reproductive age in some selected areas of Bangladesh

Dissertation for the partial fulfillment of the requirements for the degree of MPhil in Nutrition and Food Science

Submitted by:

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CERTIFICATION

This is to certify that the thesis entitled "**Association of socioeconomic condition with serum uric acid, urea and creatinine profile of women reproductive age in some selected areas of Bangladesh**" was submitted by Ferdous Ara of examination roll -07, Registration No-40, Session-(2019-20) for the degree of MPhil ,University of Dhaka, is an original piece of research work. Ferdous Ara has carried out this research work supervised by Professor Dr. Md. Saidul Arefin & Professor Dr. M. Akhtaruzaman submitted to the examination Committee for evaluation.

This research work is worthy for the award of the degree of MPhil in accordance with the rule and regulation of Dhaka University.

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Declaration

I hereby humbly declare that this thesis entitled "Association of socioeconomic condition with serum uric acid, urea & creatinine profile of women reproductive age in some selected areas of Bangladesh" based on works carried by me. No part of it has been presented for higher degree.

This work was carried out under the guidance of Prof. Dr. M. Aktarruzzaman and Prof. Dr. Md. Saidul Arefin Institute of Nutrition and Food Science, University of Dhaka.

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Abstract

Background:

In the human body the kidney plays a significant role in the homeostatic mechanism. Any disruption in kidney functionality is reflected through high levels of serum creatinine, urea and uric acid. Disruption in kidney functionality can be associated with the nutritional status of a population and their socioeconomic conditions. However, information is limited on the association between socioeconomic conditions and abnormal kidney function markers in women of reproductive age (WRA). Therefore, the goal of the study was to determine the association of socioeconomic condition and nutritional status with serum uric acid, urea and creatinine of WRA in selected areas of Bangladesh.

Methodology:

A cross-sectional study was directed among 178 WRA in different places of Bangladesh (rural Chittagong, rural Gazipur, Meherpur and Kushtia, Shatkhira). Data on demographic, socioeconomic and anthropometric variables were collected. Blood samples were also collected. DIALAB GmbH semi-automatic biochemistry analyzer DTN-405 (Austria) was used to conduct biochemical tests of the blood samples. Logistic regression analysis was used to control the association between kidney function abnormalities and associated factors.

Results:

The study results showed that about 23.6% of the study participants were underweight, 56.7 % had normal body mass index (BMI) whereas 19.7% of participants were overweight or obese. The average (mean ± SD) serum levels (mg/dl) were 5.74±2.07 for uric acid, 17.93±9.83 for urea, and 0.89±0.28 for creatinine and 92.18±35.86 mL/min/1.73 m^2 for estimated glomerular filtration rate (eGFR). Elevated levels of creatinine, uric acid, and urea were observed in 27%, 31.5%, and 41% of the participants, respectively. Additionally, chronic kidney disease (CKD)

was identified in 18% of the participants. Overall, normal kidney function markers were found among about 31% of the respondents, while 5% showed elevated levels for all three markers. The odds of having at least one or more elevated kidney function markers were significantly higher (AOR=2.8; 95% CI: 1.22-6.42; $p < 0.05$) among individuals with a BMI greater than 18.5 kg/m^2 compared to underweight women. After adjusting for related factors, BMI was found to be significantly associated with the risk of elevated kidney function markers.

Conclusion:

The study found that only one-third of the WRA had all normal kidney function markers. After adjusting for related factors BMI was found to be significantly associated with the risk of elevated kidney function markers. The findings highlight alarming information about women's health and suggest that routine analysis is desirable to improve women's health in our country. Further studies are required with a larger sample size to understand deeply and assist the relevant ministries in policy making.

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NHDSBD = Nutrition health and demographic survey of Bangladesh

BMI= Body mass index

MUAC= Mid-upper arm circumference

SAU= Serum uric acid

WRA=Woman of reproductive age

BDT= Bangladeshi Taka
eGFR= estimated Glomerular Filtration Rate

CKD= Chronic Kidney Disease

CKD-EPI= Chronic Kidney Disease epidemiology collaboration

NGO = Non-government organization

MDRD=Modification of diet in renal disease

WHO=World Health Organization

SD= Standard Deviation
IQR= Interquartile Range
TFR = Total fertility rate

Chapter 1

Introduction

Introduction:

The kidney shows a vital character in regulating homeostasis within the human body. Its major functions include regulating the body's acid-base and electrolyte balance, conservation of essential nutrients, modulating hormonal activities, and excreting metabolic end product products such as uric acid, urea and creatinine [1]. The urea is a metabolic end product of protein and nitrogen metabolism formed in the liver, facilitating the elimination of nitrogen containing compounds from the body [2]. More than 90% of urea is excreted through the kidney. Serum uric acid (SUA), the end product of purine metabolism, accumulates when purines break down. Elevated uric acid levels, known as hyperuricemia, can arise from overconsumption of high-purine-containing foods or some medications such as diuretics, aspirin and niacin. This condition can lead to the formation of uric acid crystals in the joints, causing painful inflammation known as gout [3]. Serum creatinine is the most commonly used biomarker for evaluating kidney function. The glomerular filtration rate can be estimated using either the Modification of Diet in Renal Disease (MDRD) study equation or the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula, both of which rely on serum creatinine levels [4].Creatinine is a waste product of protein metabolism and acts as a key indicator of renal function [5, 6].

The reproductive age (15-49 years) is a critical part of a woman's life. During this time, various factors—including maternal malnutrition, abnormal salt intake, placental insufficiency, alcohol use, maternal inflammation, exposure to glucocorticoids, deficiencies in vitamin A and iron, drug use, and gestational diabetes—can disrupt the kidney's early homeostatic mechanisms, potentially leading to kidney disease later on [7]. Over the past decade, objective assessments of kidney damage and function have highlighted kidney disease as a significant public health concern. Chronic kidney disease now affects over 10% of the general population and more than 50% in high-risk groups [8]. Chronic kidney disease (CKD) is becoming an increasingly significant public health concern in low- and middle-income countries (LMICs), with its prevalence rising swiftly, especially across Asia. For example, the estimated prevalence of kidney disease among the South Asian population was 13.5% [9].

The socioeconomic environment comprises a range of factors- monthly income, monthly expenditure, education, and access to healthcare- each influencing eating habits, stress levels, weight status, BMI and ultimately, health outcomes[10]. Excess weight or adiposity, characterized by elevated BMI has been strongly related with a high risk of kidney disease, including chronic kidney disease, ESRD, kidney stones, renal cancer, and renal cell carcinoma. These conditions can adversely affect renal function through mechanisms like insulin resistance and glomerular hyper filtration [11-19].Obesity and Overweight are serious public health issues around the world. According to WHO, 43% of individuals (2.5 billion) aged 18 and above were overweight, with 16% (890 million) suffering from obesity in 2022[20].This rising trend is concerning, as overweight and obesity are strongly linked to conditions such as Type 2 Diabetes Mellitus, cardiovascular disease, hypertension, high cholesterol levels, osteoarthritis, and other related health issues. [21].

For the Asian population, there are only a few studies that focus on the adverse effects of overweight and obesity with kidney function markers among women of reproductive age. This study intends to fill this gap by evaluating the association between socioeconomic conditions with serum levels of urea, uric acid, and creatinine among women of reproductive age by assessing how socioeconomic disparities may influence renal function and metabolic health in this population group. Such findings are crucial for influencing targeted interventions and policies to reduce health disparities and support optimal health outcomes for women of reproductive age.

Rationale of the study

The study was conducted by analysis of socioeconomic condition, nutritional status, serum uric acid, urea and creatinine level of non-pregnant women aged 15 to 49 years in some selected areas of Bangladesh. The association of socioeconomic condition and nutritional status with these biochemical parameters of the women were seen. Serum levels of uric acid, urea and creatinine vary with nutritional status and socioeconomic condition. Not many studies have been conducted regarding this situation.

The kidney is essential for maintaining the body’s internal balance by controlling fluid levels, regulating electrolytes, and eliminating waste products. Disruptions in kidney function are commonly identified through elevated levels of biochemical markers such as serum creatinine, urea, and uric acid. These abnormalities not only indicate potential renal dysfunction but can also be early indicators of chronic kidney disease (CKD), which often remains undiagnosed until advanced stages. Early identification of risk factors associated with kidney dysfunction is essential, particularly in vulnerable populations.

Women of reproductive age (WRA) represent a key demographic group whose health status significantly influences maternal and child health outcomes. In many low- and middle-income countries, including Bangladesh, WRA are frequently exposed to a range of health challenges stemming from poor nutritional status, limited access to healthcare, and socioeconomic disadvantages. Malnutrition—both under nutrition and over nutrition has been linked to alterations in metabolic processes that may adversely impact kidney function. Similarly, socioeconomic conditions, such as low income, inadequate education, and poor breathing environments, can limit access to quality food, healthcare services, and information, thereby indirectly influencing kidney health.

Although numerous studies have explored the impact of nutrition and socioeconomic status on general health outcomes, there remains a significant gap in research specifically focusing on their relationship with kidney function markers among WRA. Most existing literature either generalizes findings across populations or concentrates on patients with diagnosed kidney disease, thus failing to capture early-stage or subclinical manifestations in at-risk community groups. This oversight is particularly concerning in a country like Bangladesh, where disparities in health indicators remain pronounced across regions and among different population segments.

This study addresses this critical knowledge gap by examining the association between nutritional status, socioeconomic variables, and biochemical indicators of kidney function serum creatinine, urea, and uric acid—in WRA from various regions of Bangladesh. By employing a cross-sectional design and utilizing both anthropometric and biochemical measurements, the study provides a comprehensive analysis of the underlying factors contributing to abnormal kidney function markers. Notably, the use of logistic regression analysis strengthens the findings by adjusting for confounding variables, thus providing robust evidence of associations.

The findings reveal an alarming health concern, with a considerable proportion of women showing elevated kidney function markers, and a notable association between BMI and the risk of kidney dysfunction. These results underscore the urgent need for public health interventions that include routine kidney function monitoring in community-based settings, especially for women of reproductive age, the study's findings underscore the need to tackle both under nutrition and overweight/obesity, emphasizing that well-balanced nutritional approaches are essential for this population.

This study fills a vital research gap and offers actionable insights for health policymakers, practitioners, and researchers. By identifying BMI and potentially socioeconomic status as significant contributors to abnormal kidney function, the study supports the development of targeted prevention and screening programs. Moreover, the findings provide a foundation for further significant studies, which are necessary to authorize these associations and inform integrated health strategies aimed at improving women's health and preventing the long-term burden of kidney disease in Bangladesh.

Objectives

General objective:

To assess the serum uric acid, urea and creatinine levels among women of reproductive age (15-49 years) and the association of these parameters with nutritional status and socioeconomic conditions of those women in some selected areas of Bangladesh.

Specific objectives:

- To assess the serum uric acid, urea and creatinine levels among women of reproductive age (15-49 years) in the selected areas.
- To assess the nutritional status of the women using BMI and MUAC.
- To assess the socioeconomic conditions of the selected women.
- To associate these biochemical parameters with their nutritional status.
- To associate these biochemical parameters with their socioeconomic conditions.

Chapter 2

Literature Review

2.1 Structure of the Kidney

The kidney is one of the most essential organs in the human body. Any disruption in its function can result in serious health complications and may even be life-threatening. It has a highly intricate structure and performs several critical roles, primarily the elimination of harmful waste and toxins and the regulation of the body's water, fluid, mineral, and chemical balance.

The kidneys are essential for urine production, as they filter harmful substances and excess water from the bloodstream. After urine is formed, it flows through the ureters to the bladder for storage, and is eventually excreted via the urethra.

Most individuals—both male and female—have two kidneys. These bean-shaped organs are situated deep in the upper rear portion of the abdominal cavity, one on each side of the spine. They are naturally protected by the lower ribs, making them difficult to feel from outside the body.

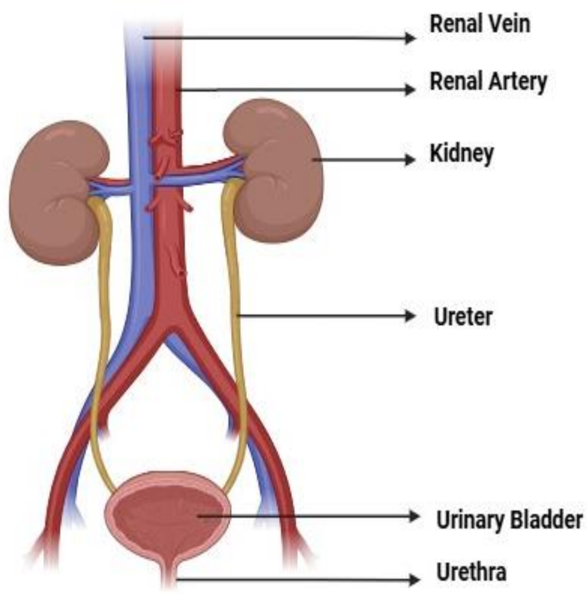

Figure 1: Structure of Kidney (Source: https://BioRender.com)

Each adult kidney is roughly 10 cm long, 6 cm wide, and 4 cm thick, with an average weight ranging from 150 to 170 grams. The ureters, which are about 25 cm in length, are muscular, hollow tubes that carry urine from the kidneys to the bladder. The urinary bladder is a hollow, muscular organ situated in the lower anterior part of the abdomen. It functions as a temporary storage site for urine until it is discharged from the body. [22]

2.2 Function of Kidney

1. Elimination of Waste Products

One of the kidney’s most vital functions is to purify the blood by removing waste products. When we consume food, especially proteins—essential for growth and tissue repair—the body metabolizes these proteins and produces waste by-products. If not properly removed, these substances can accumulate and act like toxins in the body. The kidneys act as natural filters, removing these harmful waste products from the bloodstream and expelling them through urine.

Two key waste substances—**creatinine** and **urea** are commonly used to assess kidney function. Their levels in the blood serve as indicators of how well the kidneys are working. When kidney function declines or both kidneys fail, the concentrations of creatinine and urea in the blood increase significantly.

2. Regulation of Fluid Balance

Another essential function of the kidney is maintaining the body's fluid balance. It does this by excreting excess water in the form of urine while conserving the amount of water the body needs to function properly. In this way, the kidneys help regulate and stabilize the overall water content in the body.

When the kidneys are not functioning properly, they lose the ability to remove surplus fluid. This buildup of excess water can result in swelling, particularly in areas like the feet, ankles, and around the eyes, and may lead to further complications if left untreated

3. Regulation of Minerals and Electrolytes

The kidneys also play a critical role in maintaining the proper balance of essential minerals and electrolytes in the body, such as sodium, potassium, hydrogen, calcium, phosphorus, magnesium, and bicarbonate. By carefully regulating these substances, the kidneys help ensure that the composition of body fluids remains within a healthy range.

Imbalances in these minerals can have serious health consequences. For instance, abnormal sodium levels can affect mental alertness and cause confusion, while fluctuations in potassium levels can disrupt heart rhythm and impair muscle function. Likewise, maintaining appropriate levels of calcium and phosphorus is vital for strong bones and healthy teeth.

4. Regulation of Blood Pressure

The kidneys help regulate blood pressure by producing hormones such as renin, angiotensin, aldosterone, and prostaglandins. These hormones, along with the kidneys' ability to control the balance of salt and water, play a crucial role in maintaining stable blood pressure levels.

When the kidneys are damaged or fail, this regulatory system becomes disrupted. Impaired hormone production and imbalanced salt and water levels can lead to high blood pressure (hypertension), which is both a cause and a consequence of kidney disease.

5. Stimulation of Red Blood Cell Production

The kidneys contribute to red blood cell (RBC) production by releasing a hormone called erythropoietin. This hormone signals the bone marrow to produce more RBCs, which are essential for carrying oxygen throughout the body.

When kidney function declines, the production of erythropoietin decreases. As a result, the bone marrow produces fewer red blood cells, leading to anemia—a condition characterized by low hemoglobin levels, fatigue, and weakness. This is a common complication in individuals with chronic kidney disease.

6. Supporting Bone Health

The kidneys play a vital role in maintaining healthy bones by converting vitamin D into its active form, calcitriol. This active form is necessary for the absorption of calcium from food, which is crucial for the development, growth, and strength of bones and teeth. When the kidneys fail, their ability to activate vitamin D is significantly reduced. As a result, calcium absorption decreases, leading to weakened bones and impaired bone growth. In children, growth retardation can be one of the earliest signs of kidney dysfunction due to poor bone development.[22]

2.3 Urine Formation

The kidneys receive about 1200 ml of blood per minute, which totals around 1700 liters per day, for filtration. The glomeruli filter approximately 125 ml per minute, or 180 liters per day, forming urine. The tubules then reabsorb about 99% of this fluid (around 178 liters), leaving 1 to 2 liters of urine that is excreted, containing waste products, toxins, and excess minerals.

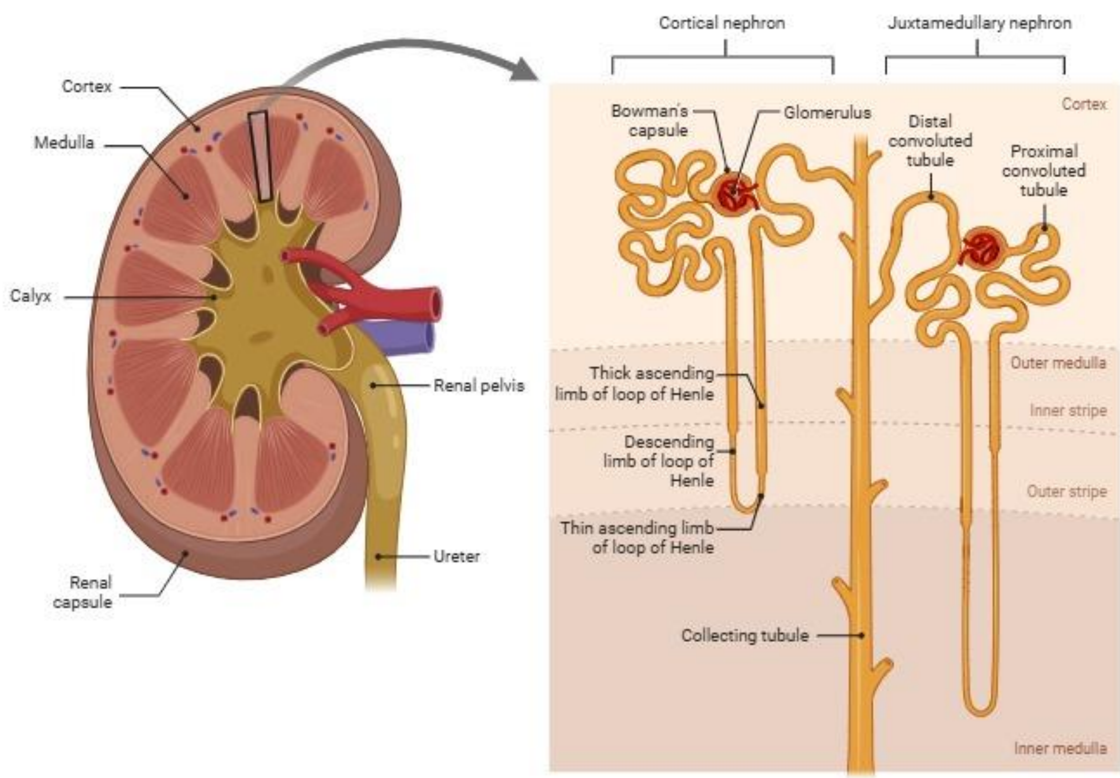

Figure 2: Structure of nephron (Source: https://BioRender.com)

2.4 Major Kidney Diseases

Kidney diseases are generally classified into two categories:

a) Medical kidney diseases: These include conditions like kidney failure, urinary tract infections (UTIs), and nephrotic syndrome. They are typically managed by nephrologists using medical treatments. In advanced cases of kidney failure, interventions such as dialysis or kidney transplantation may be required.
b) Surgical kidney diseases: Conditions such as kidney stones, prostate disorders, and cancers of the urinary tract fall into this category. These are treated by urologists through surgical procedures, endoscopic techniques, or lithotripsy.[22]

2.5 Symptoms of Kidney Diseases

1. Facial Swelling

Swelling of the face, along with the feet and abdomen, is a common symptom associated with kidney disease. A key feature of kidney-related swelling is that it typically begins around the eyes and is most prominent in the morning.

While kidney failure is a well-known cause of swelling, it's important to note that not all swelling is due to kidney failure. In some kidney conditions, such as nephrotic syndrome, swelling can occur even when kidney function remains normal. Conversely, some individuals with advanced kidney failure may not exhibit any visible swelling at all.

2. Loss of Appetite, Nausea, and Vomiting

Individuals with kidney failure often experience a reduced appetite, changes in taste, and decreased food intake. As kidney function continues to decline and waste products accumulate in the body, symptoms such as nausea, vomiting, and hiccups may develop.

3. High blood pressure - Hypertension

Hypertension is common in patients with kidney failure. If high blood pressure develops at a young age (under 30 years) or is extremely elevated when first diagnosed, it may indicate an underlying kidney problem.

4. Anemia and Weakness

Common symptoms of anemia, such as overall weakness, fatigue, reduced ability to concentrate, and pale skin, are frequently reported by individuals with low hemoglobin levels. In the early stages of chronic kidney disease, these may be the only noticeable signs. When anemia does not improve with usual treatments, evaluating for possible kidney failure becomes important.

5. Nonspecific Complaints

Symptoms such as lower back pain, generalized body aches, itching, and leg cramps are common symptoms associated with kidney problems. In children with kidney failure, issues like stunted growth, short stature, and bowed legs are frequently observed.

6. Urinary Complaints: Typical urinary symptoms include:

a. **Decreased urine output**, which often contributes to swelling, is a common feature of many kidney disorders.
b. **Burning sensation during urination**, increased frequency, and the presence of blood or pus in the urine usually indicate a urinary tract infection (UTI).
c. **Urine flow obstruction** may cause difficulty or straining during urination, weak urine stream, or dribbling. In more severe cases, complete inability to urinate may occur.[22]

2.6 Diagnosis of Kidney Diseases

1. Urine test:

- Routine urine tests
- 24 hours urine for albumin
- Culture and sensitivity test

2. Blood test:

- Creatinine, Uric acid and Urea
- Hemoglobin
- Blood sugar, serum protein, cholesterol, Serum electrolytes

3. Radiological Tests

- Ultrasound of kidney
- X-ray of abdomen
- Intra venous urography (IVU)

4. Other Special Tests

- Kidney biopsy,
- Cystoscopy

2.7 Uric acid

Uric acid is a waste product naturally produced by the body when purines are broken down. Purines are substances present in the body and in certain foods such as liver, shellfish, and alcoholic beverages. They can also be generated when DNA is broken down. Normally, uric acid is eliminated from the body through urine or stool. However, if the body produces too much uric acid or the kidneys are not functioning properly, it can accumulate in the bloodstream—a condition known as hyperuricemia. Elevated uric acid levels may also result from consuming excessive amounts of purine-rich foods or using certain medications, such as diuretics, aspirin, or niacin. When uric acid builds up, it can form crystals that deposit in the joints, leading to painful inflammation known as gout. [23]

2.8 Urea

The liver generates urea when amino acid breakdown. Urea production increases after consuming a protein-rich meal or during discriminating internal protein breakdown, such as in cases of infection, internal bleeding, poisoning, fever, or tissue damage. In healthy individuals, the kidneys efficiently excrete large amounts of urea without causing a rise in its concentration in the blood. Urea clearance is influenced by factors like hydration status and the use of diuretics. When the body is dehydrated, urea levels in the blood tend to rise.

Causes of increased urea concentration:

A. When creatinine is also elevated:

- Impaired kidney function
- Post-renal obstruction
- Reduced renal blood flow

B. When creatinine remains normal:

1. Increased tissue breakdown
2. Sodium deficiency (often due to diuretics)

Causes of decreased urea concentration:

a. Low protein intake

b. Cachexia (severe muscle wasting)

c. Severe liver failure.[24]

2.9 Creatinine

Creatinine levels can sometimes be used as an indirect indicator of muscle mass. When kidney function is normal, a low creatinine level may reflect reduced muscle mass. Creatinine is produced through the breakdown of creatine, which occurs in muscle tissue.

Factors that may lead to elevated creatinine levels include:

a. Reduced glomerular filtration rate (GFR)

b. Obstruction in the urinary tract (post-renal)

c. Significant pre-renal conditions such as hypotension or shock

d. High levels of catabolic activity

Factors that may cause decreased creatinine levels include:

- Low muscle mass [24]

2.10 Prevention of kidney diseases

Kidney diseases often progress quietly, gradually damaging kidney function until complete kidney failure occurs. At this stage, patients typically need dialysis or a kidney transplant to survive and maintain a healthy life. However, in many developing countries, due to high costs and limited access, only 5–10% of patients with kidney failure receive such treatments. Unlikely, the majority go untreated and may die without definitive care.

Chronic kidney disease (CKD) is widespread and currently has no cure, making prevention crucial. Detecting CKD early and starting timely treatment can slow its progression and help avoid or postpone the need for dialysis or a transplant. [22]

Never overlook your kidneys. Key points for preventing and managing kidney disease are divided into two categories:

1. Precautions for healthy individuals.
2. Precautions for those with kidney conditions.

2.11 Chronic Kidney Disease

Chronic kidney disease (CKD) is characterized by a gradual and irreversible loss of kidney function occurring over months or years. Important signs of CKD include increased serum creatinine levels in blood tests and ultrasound results revealing that both kidneys are small and shrunken.

The term "chronic renal failure" (CRF) was commonly used in the past and is nearly equivalent to CKD. However, CKD is now preferred, as the term "kidney failure" can misleadingly suggest that the kidneys have completely stopped functioning. In reality, most individuals with CKD experience only a mild to moderate loss of kidney function, rather than total kidney failure.

Symptoms of chronic kidney disease (CKD) vary according to the stage of the disease. To better understand and manage CKD, it is divided into five stages based on the glomerular filtration rate (GFR). GFR measures how well the kidneys filter waste from the blood and is usually estimated using blood creatinine levels. It is a dependable indicator of kidney function, with a normal GFR being above 90 ml/min. [22]

Stage	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
	Normal GFR	Mild CKD	Moderate CKD	Severe CKD	End Stage CKD
GFR	> 90 ml/min	60-89 ml/min	30-59 ml/min	15-29 ml/min	<15 ml/min

2.12 Nutrition

Malnutrition plays a major role in complicated pregnancies and contributes significantly to high rates of maternal and infant mortality. This issue often spans generations, as undernourished mothers tend to give birth to babies who face growth and health challenges. Malnourished children are typically weak, have low immunity, perform poorly in school, and tend to be less productive in adulthood. Although there have been some modest improvements over the years, the nutritional health of women in Bangladesh remains a serious concern. Nearly one in three women of reproductive age have a body mass index (BMI) below 18.5, indicating they are severely underweight. Girls are slightly more prone to stunting and being underweight than boys of the same age. [25]

Poor diet and insufficient food intake are the primary drivers of malnutrition. Vitamin A deficiency, particularly harmful to pregnant and breastfeeding women, increases the risk of maternal death. Anemia is another critical public health issue, affecting around 30% of adolescent girls (compared to 26% of boys) and nearly half of all pregnant women. In children under two, boys are more frequently affected by anemia. This condition not only contributes to maternal and child mortality but also weakens the immune system and hampers physical growth, cognitive development, productivity, and birth outcomes. [26]

Additionally, iodine deficiency is more prevalent among girls than boys, with 37% of girls and 31% of boys lacking adequate iodine. Since iodine is essential for fetal brain development, the fact that over a third of pregnant women are iodine deficient is particularly alarming. [27]

2.13 Nutritional status

Nutritional status refers to the present physical condition of an individual or group based on their level of nourishment. One of the most effective ways to assess this is through anthropometric measurements. Nutritional status is influenced by a combination of internal (or personal) and external (or environmental) factors, such as:

1. **Internal or personal factors:** including age, gender, diet, calorie consumption, and type of work.
2. **External or environmental factors:** such as the safety of food, level of education, understanding of nutrition, and social and economic conditions.

2.14 Anthropometry

Anthropometry involves the measurement of an individual's height, weight, and body proportions. According to Jelliffe (1966), Nutritional Anthropometry refers to "the assessment of variations in physical dimensions and overall body composition across different ages and nutritional conditions." In 1951, the FAO/WHO Joint Expert Committee recognized anthropometry as a key method for assessing the nutritional status of populations. [28]

Common anthropometric measurements include:

- Body height or length
- Body mass (weight)
- Mid-upper arm circumference (MUAC)
- Arm span or demi-span
- Knee height
- Skinfold thickness
- Head circumference

2.15 Reproductive Health

Regarding maternal healthcare, 58.7% of women who gave birth in the two years before the In Bangladesh, the Total Fertility Rate (TFR) is 2.3, meaning that, on average, a woman gives birth to 2.3 children over her reproductive lifespan. The adolescent birth rate is relatively high, with 83 births per 1,000 girls aged 15 to 19. Early motherhood is also prevalent—approximately 24.4% of women aged 20–24 gave birth before turning 18.

Contraceptive use is fairly widespread, with 61.8% of currently married women aged 15–49 using some form of contraception, and 59.3% relying on modern methods. The unmet need for contraception in this group is relatively low at 13.9%.

Survey received at least one antenatal checkup from a skilled healthcare provider, though only 24.7% had the recommended four visits. Additionally, 38% underwent blood pressure checks and provided urine and blood samples during these visits. Access to antenatal care varies significantly based on location, education level, and household wealth.

Only 31% of births occurred in healthcare facilities, and just 43.5% were assisted by trained health professionals. Caesarean deliveries accounted for 19.1% of births. Women with secondary or higher education were five times more likely to deliver in a health facility compared to women with no education.

Among women aged 15–49 who had given birth in the previous two years, 82.8% stayed in a health facility for at least 12 hours after delivery. However, only 41.2% of newborns and 40.4% of mothers received a health check within two days post-delivery. The availability and quality of postnatal care services vary widely across regions and between urban and rural populations, with education and economic status playing a key role in access to and quality of care. [31]

2.16 Education

Education plays a crucial role in achieving good nutritional status. Educated girls are probable to delay marriage, seek medical assistance during childbirth, and give birth to healthy children who are more likely to survive and succeed into adulthood. Bangladesh has made significant progress in promoting girls' education, with girls now outstripping boys in both primary and secondary schools. [29] However, presence rates at the secondary level remain low, with only 53% of girls and 46% of boys attending. [30]At the tertiary level, gender disparity is still evident, with only six women enrolled for every ten men—falling short of the Millennium Development Goal for gender equality. Additionally, older women generally have lower educational attainment than men of the same age. Data from the Bangladesh Bureau of Statistics shows that 63% of men over the age of 15 are literate, compared to just 55% of women. [32]

2.17 Effort

Over the past two decades, women in Bangladesh have made notable gains in the formal workforce, largely due to their growing involvement in the garment industry and the expansion of microcredit programs led by NGOs that focus on empowering women. Despite this progress, the 2007 Bangladesh Demographic and Health Survey reported that approximately 65% of women aged 15–49 were not employed in the year prior to the survey, compared to just 2% of men in the same age group. Moreover, among the women who do earn an income, one in eight does not have control over how their earnings are spent. [33]

Child labor remains widespread in Bangladesh, with enforcement of national laws against it being minimal. Around 8–9% of girls aged 5 to 14 are employed, but many work in hidden and informal sectors, such as domestic labor and commercial sex work.[34] Girls, in particular, often lack the right to earn and control their own wages. A 2006 study by the International Labor Organization revealed that 58% of female child domestic workers received no financial compensation, and when they were paid, their parents typically collected the wages. [35]

Child labor can put children at risk of both physical and sexual abuse. Those who work away from their families are particularly vulnerable and may be drawn into the commercial sex trade. It is estimated that up to 150,000 women and girls are involved in commercial sex work. Children exploited in this industry are frequently deprived of education and healthcare. [36] One study found that just 0.5% of girls in commercial sexual exploitation attended school, and more than half had contracted a sexually transmitted infection. [37]

2.18 Difficulties

Women and children are especially vulnerable during emergencies like natural disasters, which occur frequently in Bangladesh. Limited mobility and a lack of decision-making power make women more susceptible to harm or death during events such as cyclones and floods. For example, during the 1991 cyclone in Bangladesh, an overwhelming 90% of the fatalities were women. [38]

In the aftermath of disasters, protection risks often escalate as normal social and safety systems collapse. Without the security of their usual homes, women and children face greater threats of violence, abuse, and exploitation. Following the 1998 floods, for instance, there was a noticeable rise in the number of girls migrating to Dhaka to enter sex work. [39]

2.19 Socio-economic correlates of malnutrition among the married women; Bangladesh perspective:

In 2005, poverty affected 40% of Bangladesh's population, according to the Cost of Basic Needs (CBN) measure. The poverty rate was higher in rural areas (43.8%) than in urban regions (28.4%). [40] Poverty is a key underlying factor contributing to malnutrition. [42] Women of reproductive age are particularly vulnerable to malnutrition due to both biological and social factors.

The patterns and severity of protein-energy malnutrition and micronutrient deficiencies within a population are shaped by multiple factors. These include the political and economic climate, education levels, sanitation, seasonal and environmental conditions, food availability and production, cultural and religious dietary customs, breastfeeding practices, the spread of infectious diseases, the presence and efficiency of nutrition initiatives, and access to quality healthcare. [41]

Malnutrition—commonly defined by being underweight—is a serious public health concern, closely linked to elevated risks of illness and death. [41] Women and young children are disproportionately affected. Diets lacking in macronutrients such as protein, carbohydrates, and fats can lead to protein-energy malnutrition.[43] Both underweight and overweight conditions result from imbalanced energy intake—either too little or too much—and each poses different health risks. Obesity is associated with chronic conditions such as diabetes, cardiovascular diseases, cancer, stroke, and respiratory problems, while being underweight is linked to preterm births, low birth weights, child malnutrition, poor mental health, and increased mortality. [44] Globally, underweight remains a leading cause of death and disability, especially in low-income countries. [45]

In Bangladesh, malnutrition in women and children is caused by factors such as inadequate food intake, unequal food distribution within families, unsafe food practices, dietary restrictions, exposure to infections, and insufficient care. For women, the nutritional demands of pregnancy and breastfeeding add to these challenges. Deep poverty, limited education, and cultural taboos often result in women eating less and after other family members. Many poor women experience chronic under nutrition, frequent illnesses, and limited access to healthcare. They also bear the responsibilities of household work and frequent pregnancies, often starting from adolescence.

In Bangladesh, as in many other developing countries, malnutrition among women not only compromises their own health but also has detrimental effects on their children's well-being. Poverty, lack of education, and deep-rooted social taboos significantly limit women's food intake; they are often the last to eat and receive the smallest portions within a household. Many impoverished women endure the long-term impacts of chronic under nutrition, frequent illnesses, and limited access to healthcare services. In addition to these challenges, women are primarily responsible for managing daily household tasks. The burden of repeated pregnancies beginning in early adolescence, combined with domestic responsibilities, places immense physical strain on them. Adolescent pregnancies and protein-energy malnutrition are particularly prevalent issues. Malnutrition in women is especially concerning, as inadequate nutrition adversely affects both maternal and child health.

There is a scarcity of research exploring the relationship between women's socio-economic conditions and their nutritional status in Bangladesh. This study seeks to examine how socio-demographic and other selected factors are associated with the risk of underweight among ever-married, non-pregnant women in the country. [45]

Chapter 3

Methodology

Materials and Methods:

3.1 Study design

The Nutrition, Health, and Demographic Survey of Bangladesh 2011 (NHDSBD-2011), a cross-sectional national survey, was used to select study participants. The countries demographic profile, including population dynamics, health indicators, nutritional status, agricultural practices, and food security, was provided in depth by NHDSBD-2011[45]. A two-stage stratified random sampling procedure, based on the integrated multipurpose sample (IMPS) design created from the Population and Housing Census 2001, was used to choose participants.

3.2 Study population

Households were carefully selected from sampling units located throughout Bangladesh's seven administrative divisions. After conducting detailed interviews using a standardized questionnaire, blood samples were taken from a selection of women aged 15 to 49 who were disease-free for further examination. Details of the study design have been described elsewhere [46].

3.3 Sample Size Calculation (by using the Cochran formula)

The estimated prevalence of kidney disease among south Asian population was 13.5%

$$n = z^2 \text{ x } \frac{pq}{d^2}$$

$$= (1.96)^2 \text{ x } \frac{0.135\ (1-0.135)}{(0.05)^2}$$

$$= 179.44 \approx 180$$

Here,

n = Sample size

z = 1.96 (for 95% CI)

p = Estimated prevalence (13.5%)

q = 1-p

d = Margin of error (5%)

The study included 178 women from Chittagong, Gazipur, Narsingdi, Meherpur, Kushtia, and Satkhira. Their blood samples were examined to determine the presence of abnormal kidney function markers (serum urea, uric acid and creatinine)

3.4 Demographic data and Sample Collection

A questionnaire was developed in the NHDSBD-2011 survey to obtain information on the socioeconomic status of the subjects' families were collected by interviewing the subjects. Quantitative data were collected. Some parameter and sub-parameters of the questionnaire are following: Socio-economic condition (Age, Marital status, Occupation, Education, Residence, Monthly family income, Monthly food expenditure) Anthropometric data (Height, Weight, BMI)

A precision bathroom scale (Tanita HA-622, Tanita Corporation, and Tokyo, Japan) was used to record each participant's weight while they were barefoot. A height scale was used to record each participant's height to the closest 0.1 cm.

3.5 Blood Collection

The serum levels of urea, uric acid, and creatinine in women were determined by analyzing a total of 178 samples. A medical team made up of paramedics and physicians collected and processed blood samples following the protocols [47].

Before supplying their blood samples, participants were required to fast for a minimum of eight hours. Using disposable syringes, about 6 ml of venous blood was drawn and put into simple, dry vacationer tubes for analysis. After that, the serum samples were ready and kept in a freezer at -20 °C. The serum samples were delivered from the collection sites to Dhaka using dry ice in an insulated container, maintaining correct temperature control and conserving the samples during transportation to ensure sample integrity.

3.6 Biochemical analysis

Using the semi-automatic biochemistry analyzer DTN-405 from DIALAB GmbH (Austria), the levels of creatinine, uric acid, and urea were measured in the serum.

3.6.1 Estimation of Serum Uric Acid Level

Method:

Uric acid was determined by the method of Trinder et al,1969.

Liquid uric acid Uricase - PAP For in -vitro diagnostic use only. [48, 49]

Principle

Uric acid in the sample is converted to allantoin and hydrogen peroxide by the enzyme uricase. The hydrogen peroxide produced is then detected using a chromogenic oxygen acceptor with the help of peroxidase. The resulting red quinone dye is directly proportional to the uric acid concentration in the sample.

$$\text{Uric Acid} + 2H_2O + O_2 \xrightarrow{\text{Uricase}} \text{Alantoine} + CO_2 + H_2O_2$$

$$2H_2O_2 + \text{dichlorophenol} + \text{4-AP} \xrightarrow{\text{POD}} \text{Red quinine} + 4H_2O$$

Reagent supplied

R1 Phosphate buffer 100mmol/l Detergent 1.5g/l Dichlorophenolsulphonate 4mmol/l Uricase >0.12 U/ml Ascorbate oxidase >5 U/ml Peroxidase >1 U/ml 4-Aminoantipyrine 0.5mmol/l pH 7.8 Uric Acid Standard 6mg/dl

Procedure

1. Uric acid reagent and serum sample were taken in a 40:1 ratio and mixed well in an Eppendorf.

2. The Eppendorfs were incubated at room temperature for 10 min.

3. Then the concentration of uric acid of each samples were read by a semi chemical analyzer at 520nm wavelength against reagent blank.

3.6.2 Estimation of Serum Urea Level

Method

Urea was determined by the method of Chaney et al, 1962.

Urease/Salycilate Enzymatic colarimetric method Endpoint. [50, 51, 52, 53, 54, 55]

Principle

Urea is broken down by the enzyme urease into ammonia and carbon dioxide. The released ammonia then reacts with alkaline hypochlorite and sodium salicylate in the presence of sodium nitroprusside, which acts as a coupling agent, to produce a green-colored compound. The intensity of this green chromophore is directly proportional to the amount of urea present in the sample.

UREASE

Urea + H2O ------------> 2 NH3 + CO2

NITROPRUSSIDE

NH4 + + Salycilate + NaClO ------------> Indophenol + NaCl

OH

Reagents for Urea Assay:

- R1: Enzyme Reagent
  Contains urease (>500 U/mL) and stabilizers.
- R2: Buffered Chromogen
  - Phosphate buffer: 20 mmol/L (pH 6.9)
  - EDTA: 2 mmol/L
  - Sodium salicylate: 60 mmol/L
  - Sodium nitroprusside: 3.4 mmol/L

- R3: Alkaline Hypochlorite
    - Sodium hypochlorite: 10 mmol/L
    - Sodium hydroxide (NaOH): 150 mmol/L

Procedure

1. R1, R2 and serum sample were taken in 4:96:1 ratio and mixed well in test tubes.

2. The test tubes were incubated at room temperature for 10 min.

3. Then 1000µl R3 was added and mixed well and again incubated for 10 min.

4. Then the concentration of urea of each samples were read by a semi chemical analyzer at 620nm wavelength against the reagent blank.

3.6.3 Estimation of Serum Creatinine Level

Method

Creatinine was determined by the method of Fabing D.L and Erthinghausen G. et al, 1971.

Kinetic method without deproteinisation – Jaffe reaction. [56, 57]

Principle

In the Jaffe reaction, creatinine reacts with alkaline picrate to form a reddish-orange complex. The intensity of this color, measured at 490 nm, is directly proportional to the concentration of creatinine in the sample.

Alkali

Creatinine + sodium picrate ----------> creatinine – picrate complex (reddish–orange)

Reagent Composition :

1. Picric Acid: 35 mmol/L
2. Sodium Hydroxide (NaOH): 320 mmol/L
3. Creatinine Standard: 2 mg/dL (equivalent to 177 µmol/L)

Procedure

R1 and R2, and a serum sample, were taken in a 5:5:1 ratio and mixed well in test tubes. 2. Test tubes were incubated at room temperature for 30 seconds. 3. Then the concentration of creatinine of each sample was read by a semi-chemical analyzer at 490nm wavelength against air.

3.7 Quality Control

Twelve samples were tested twice to estimate the coefficient of variation (CV), and every twenty samples were reanalyzed to confirm accuracy.
Using the formula CV = (Standard Deviation [SD]/Mean estimated value of the sample) * 100, the CV was produced. From the repeated sample analyses, the average CV for creatinine, urea, and uric acid were 2.45, 4.52%, and 3.12%, respectively.

Table: 3.7.1: Coefficient of variance of quality control test

Parameter	Creatinine	Urea	Uric acid
Coefficient of variance	2.45	4.52	3.12

3.8 Exposure variables

The demographic and socioeconomic data were presented categorically. Because of the low presence of teenagers and elderly women, participants were divided into three age groups: 23 and under, 24 to 28 years, and 29 and up. Unmarried, married, or other were the three categories of marital status. Monthly family income, food expenditures, and housing area were all included in household data. Monthly family income was divided into three categories: 8,000 Bangladeshi Taka (BDT) or less, 8,001-15,000 BDT, and greater than 15,000 BDT. Monthly food expenses were classified as low (up to 6,550 BDT), medium (6,551-9,640 BDT), and high (more than 9,640 BDT). Body Mass Index (BMI) was assessed using both Asian and World Health

Organization (WHO) classification standards. According to Asian criteria, individuals are categorized as underweight (<18.5 kg/m²), normal weight (18.5–23 kg/m²), overweight (23.5–27.4 kg/m²), or obese (≥27.5 kg/m²) [58]. The WHO classification defines underweight as <18.5 kg/m², normal weight as 18.5–24.9 kg/m², overweight as 25–29.9 kg/m², and obesity as ≥30 kg/m² [59].

3.9 Outcome variables

Normal creatinine levels were defined as serum creatinine <1.2 mg/dL [60]; normal uric acid levels as serum uric acid <5.8 mg/dL [61]; and normal urea levels as serum urea ≤20 mg/dL [60]. Participants with one or more values exceeding these thresholds were classified as having elevated kidney function markers.

The estimated glomerular filtration rate (eGFR) was calculated using the Modification of Diet in Renal Disease (MDRD) equation:

$eGFR = 186.3 \times (Creatinine)^{\wedge -1.154} \times (Age)^{\wedge -0.203}$,

with an additional multiplication factor of 0.742 for females [62].

Chronic kidney disease (CKD) was defined as an eGFR of < 60 mL/min/1.73 m², whereas non-CKD was classified as an eGFR of ≥ 60 mL/min/1.73 m² [63].

3.10 Statistical analysis

All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics were calculated for all variables, with medians and interquartile ranges (IQRs) reported due to the data's non-normal distribution. The chi-square test was utilized to assess relationships between factors such as age, monthly spending, education level, and BMI with kidney function markers (serum urea, uric acid, and creatinine levels). Variables demonstrating a p-value below 0.2 were subsequently included in the logistic regression analysis

3.11 Ethical approval

The study was established with authorization from the Ethical Board of the Faculty of Biological Science, University of Dhaka (approval no. 10/Bio. Sci./2015-2016, on October 25, 2015). Written consent was obtained from all members before data and sample collection. Anthropometric data, dietary data and socioeconomic status were also collected.

Inclusion criteria:

- Among women of reproductive age (15-49 years)
- Non lactating and non-pregnant women were included
- Self-reported healthy population

Exclusion criteria:

- Only women of reproductive age (15-49 years)
- Non lactating and non-pregnant women were included

Reliability:

Reliability refers to the consistency of the results. In this study, reliability can be ensured by using standard laboratory methods to measure serum uric acid, urea, and creatinine, calibrated equipment, and a pre-tested questionnaire for socioeconomic data. Proper training of data collectors also helps to produce consistent results.

Validity:

Validity means how accurately the study measures what it intends to measure. Using accepted biochemical tests for uric acid, urea, and creatinine ensures accurate measurement of kidney-related biomarkers. Including important socioeconomic factors such as education, income, and occupation helps improve the validity of the study. The samples were measured by using quality control to estimate the coefficient of variation (CV), and every twenty samples were reanalyzed to confirm accuracy.

Bias:

Bias refers to systematic errors that may affect study results. Possible biases include selection bias (non-representative participants), information bias (incorrect socioeconomic data), and measurement bias (laboratory errors). These can be minimized through random sampling, standardized data collection, and proper laboratory procedures.

Chapter 4

Results

Results

Table 1 displays the basic characteristics of the study population (n = 178). Among the participants, 36% of the women were aged between 24 and 28 years, with a median age of 25 years. About 96.1% of the women were married, and 91.6% were housewives. Nearly half of the participants (48.9%) had not completed secondary education. The median monthly income and food expenditure were BDT 10,000 and BDT 7541.50, respectively. The median BMI of the participants was 20.54 kg/m^2. According to the Asian cutoff, about 19.7% of the women were overweight. The median MUAC of the participants was 242cm.

Table 1: Basic demographic characteristics of the study population (N=178)

Variable	Categories	n(%)
Age (years)	≤23	65 (36.5)
	24 - 28	64 (36.0)
	>29	49 (27.5)
	Mean ± SD	25.69 ± 5.66
	Median (IQR)	25.00 (22.00, 29.00)
	Range	13-50
Marital status	Unmarried	7 (3.9)
	Married	171 (96.1)
Education level	Functionally illiterate *(0–5 years)*	64 (36.0)
	Secondary incomplete *(6–9 years)*	87 (48.9)
	Secondary complete or above *(>10 years)*	27 (15.2)
Occupation	Housewife	163 (91.6)
	Other	15 (8.4)
Residence	Rural	120 (67.4)
	Urban	58 (32.6)
Monthly food expenditure	≤6,550.00	58 (32.6)
	6,551.00 – 9,640.00	62 (34.8)

(BDT)	≥9,641.00	58 (32.6)
	Mean ± SD	10,076.60 ± 8,817.21
	Median (IQR)	7,541.50 (5,900, 11,525)
	Range	2,750-90,000
Monthly family income (BDT)	≤8,000	69 (38.8)
	8,001 – 15,000	70 (39.3)
	≥15,001	39 (21.9)
	Mean ± SD	13,979.15 ± 12,501.84
	Median (IQR)	10,000.00 (7,000.00, 15,000.00)
	Range	2,500- 80,000
BMI (*kg/m²*) (Asian)	Underweight *(<18.5*)	42 (23.6)
	Normal (*18.5–22.9)*	101 (56.7)
	Overweight or Obese *(≥23.0)*	35 (19.7)
	Mean ± SD	21.15 ± 3.44
	Median (IQR)	20.54 (18.64, 22.53)
	Range	15.96-32.30
MUAC (cm)	Mean ± SD	244±30
	Median (IQR)	242
	Range	154-342

*BDT= Bangladeshi Taka; BMI= Body Mass Index; SD= Standard Deviation; IQR= Interquartile Range

Figure 1 and 2 compares the distribution of BMI categories among participants using both the WHO and Asian cutoff points. At the Asian cutoff, the majority were of normal weight (101, 56.7%), followed by overweight (35, 19.7%) and underweight (42, 23.6%). However, applying the WHO resulted in a lower percentage of normal weight (91, 51.2%), with overweight (37, 20.6%) and underweight (47, 26.5%) participants.

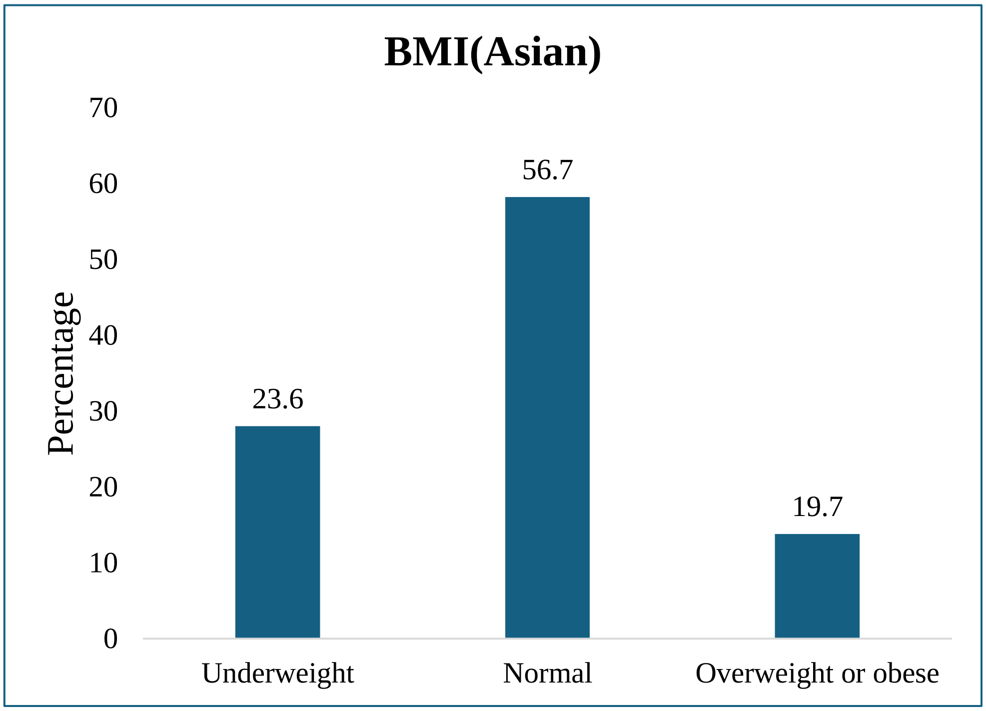

Figure 3: Nutritional status of participants according to Asian cut off.

(Underweight t<18 *kg/m²*,normal18.5-24.9 *kg/m²*, overweight>25 *kg/m²*)

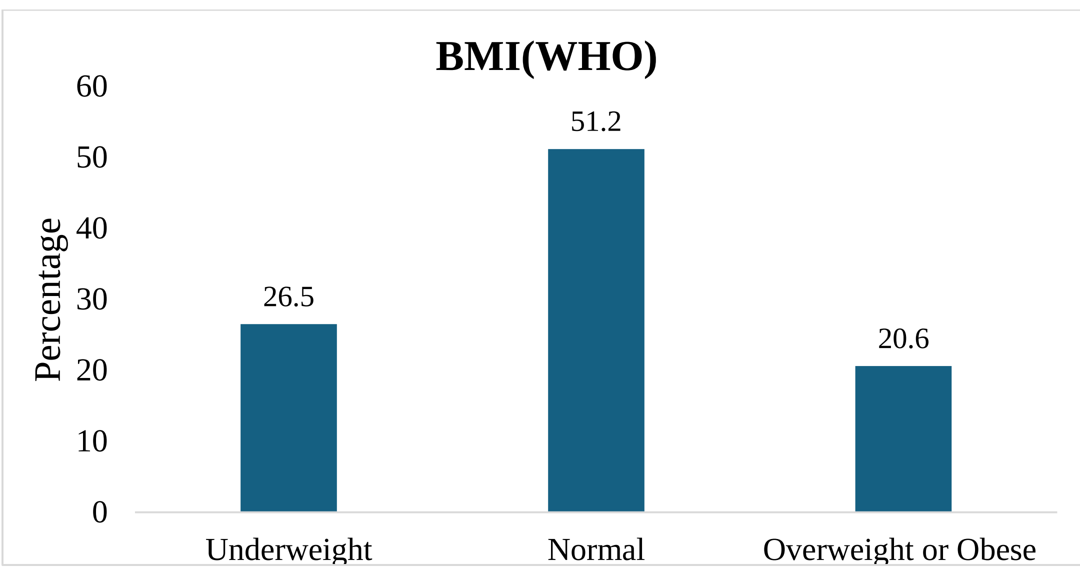

Figure 4: Nutritional status of participants according to WHO (Underweight<18 *kg/m²*,normal18.5-24.9 *kg/m²*, overweight>25 *kg/m²*)

Table 2: Biochemical parameters of kidney function marker of WRA

Variable	Mean ± SD	Median (IQR)	Range
Creatinine (mg/dL)	0.89 ± 0.28	0.88 (0.72, 1.00)	0.28-1.86
Uric Acid (mg/dL)	5.75 ± 2.07	5.41 (4.56, 6.21)	2.42, 12.97
Urea (mg/dL)	17.93 ± 9.83	15.76 (11.79, 19.86)	4.47, 50.14
eGFR (mL/min/1.73 m²)	92.18 ± 35.86	84.57 (71.78, 106.48)	33.86, 310.00

* eGFR= estimated Glomerular Filtration Rate

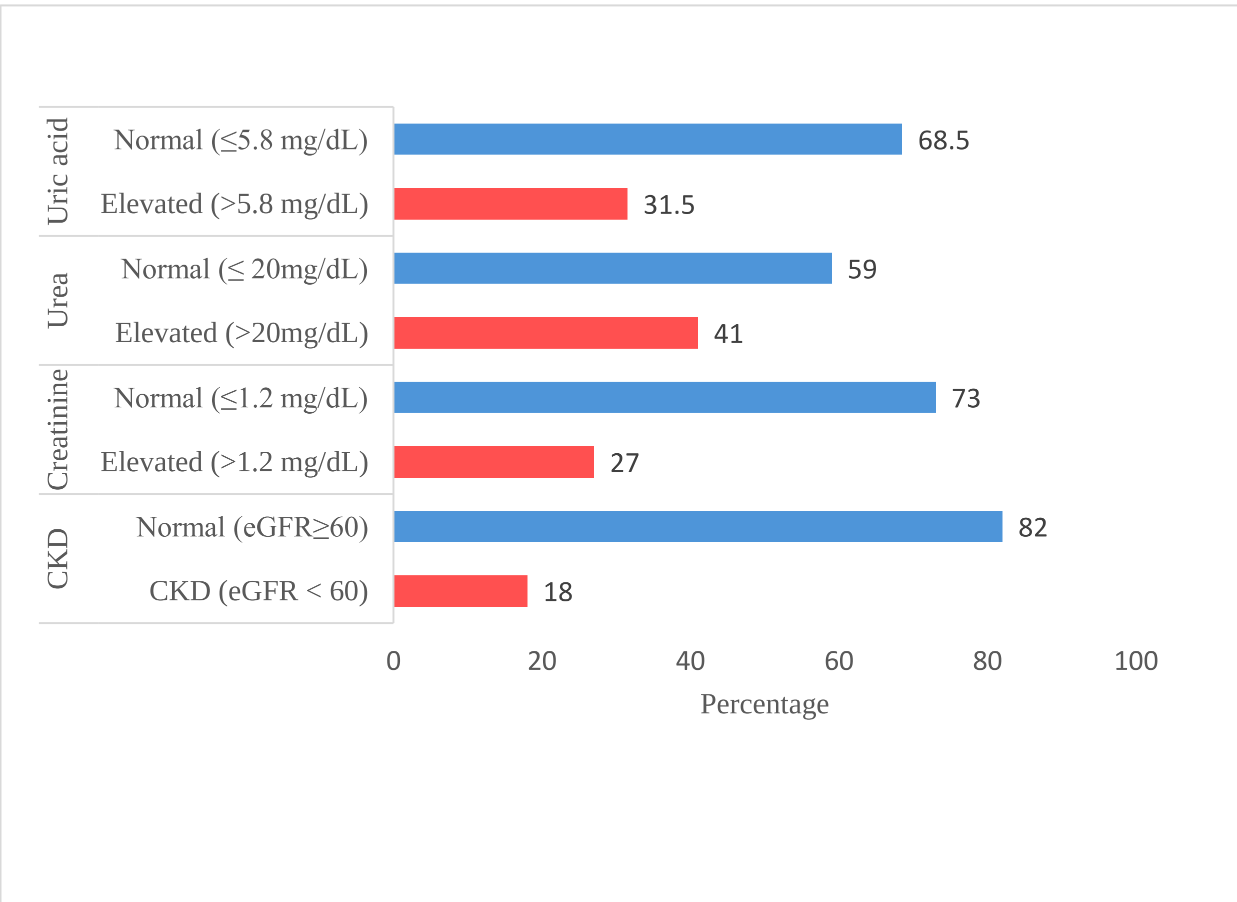

Figure 5: Distribution of participants with normal and elevated kidney function markers

Elevated values were defined as follows - uric acid >5.8 mg/dL, urea >20 mg/dL, and creatinine ≥1.2 mg/dL. CKD was defined as GFR <60 mL/min/1.73 m²; non-CKD as GFR ≥60 mL/min/1.73m².

*CKD= Chronic Kidney Disease; eGFR= estimated Glomerular Filtration Rate

Figure 5 illustrates that elevated serum uric acid, urea and creatinine levels were observed in 31.5%, 41% and 27% participants, respectively. Additionally, CKD was present in 18% of the participants.

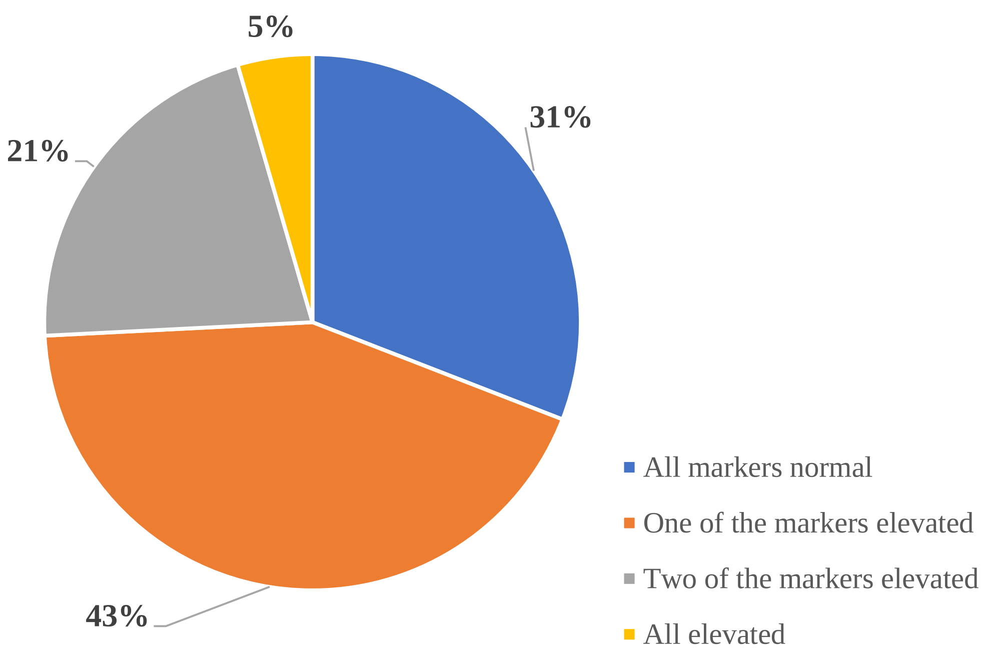

Figure 6: Prevalence of elevated kidney function markers.

Figure 6 illustrates that when the three parameters (serum urea, uric acid, and creatinine) were taken into consideration altogether only about 31% of the women had all three of them within normal range. In contrast, 43% of participants had at least one elevated marker, while only 5% had all three markers elevated.

Factors affecting elevated kidney function

As presented in table 3, individuals with one or more elevated kidney function markers were predominantly (39.8%) aged between 24 and 28 years, had secondary incomplete education (53.7%), and maintained a normal BMI (60.2%). Approximately 41% of these individuals reported an average monthly income of BDT 8,001 to 15,000, while about 37% had food expenditures ranging from BDT 6,551 to 9,640.

Table 3: Association of different factors with elevated kidney function makers (urea, uric acid and creatinine) among WRA

Variable	Categories	All three normal markers (n=55)	One or more elevated markers (n=123)	*p*-value
Age	≤23	21 (38.2)	44 (35.8)	0.207
	24 - 28	15 (27.3)	49 (39.8)	
	≥29	19 (34.5)	30 (24.4)	
Occupation	Housewife	49 (89.1)	114 (92.7)	0.425
	Other	6 (10.9)	9 (7.3)	
Residence	Rural	35 (63.6)	85 (69.1)	0.472
	Urban	20 (36.4)	38 (30.9)	
BMI (kg/m²)	Underweight (<18.5)	19 (34.5)	23 (18.7)	0.070
	Normal (18.5–22.9)	27 (49.1)	74 (60.2)	
	Overweight or Obese (≥23.0)	9 (16.4)	26 (21.1)	
Education level	Functionally illiterate	26 (47.3)	38 (30.9)	0.094
	Secondary incomplete	21 (38.2)	66 (53.7)	
	Secondary complete or above	8 (14.5)	19 (15.4)	

Monthly family income (BDT)	≤8,000	27 (49.1)	42 (34.1)	0.114
	8,001 – 15,000	20 (36.4)	50 (40.7)	
	≥15,001	8 (14.5)	31 (25.2)	
Monthly food expenditure (BDT)	≤6,550.00	24 (43.6)	34 (27.6)	0.109
	6,551.00 – 9,640.00	16 (29.1)	46 (37.4)	
	>9,641.00	15 (27.3)	43 (35.0)	

BDT= Bangladeshi Taka; BMI= Body Mass Index

Table 4 illustrates that, in the logistic regression analysis, BMI (18.5–22.9 kg/m²) was significantly associated with an increased risk of having at least one elevated kidney function marker among women after adjusting for age, monthly expenditure, and education. The odds of having one or more elevated kidney function markers was significantly ($p<0.05$) 2.8 times higher when the BMI is greater than 18.5 kg/m^2 (Table 4). However, none of the socio-demographic factors were significantly associated with CKD. No significant association between BMI and CKD (calculated from eGFR) was observed in our study (data not shown).

Table 4: Factors associated with the prevalence of at least one elevated kidney function makers (serum creatinine, urea, uric acid levels)

Variable	**Categories**	**COR (95% CI)**	***p*-value**	**AOR (95% CI)**	***p*-value**
Age (Years)	≤23	1		1	
	24 - 28	1.56 (0.72, 3.39)	0.263	1.25 (0.53, 2.93)	0.607
	>29	0.75 (0.35, 1.64)	0.474	0.56 (0.23, 1.36)	0.199
	Functionally illiterate	1		1	

Education level	Secondary incomplete	2.15 (1.07,4.33)	.032*	2.08 (0.98, 4.44)	0.057
	Secondary complete or above	1.63 (0.62, 4.27)	0.324	1.3 (0.45, 3.74)	0.630
Monthly food expenditure (BDT)	≤6,550.00	1		1	
	6,551.00 – 9,640.00	2.03 (0.94, 4.39)	0.073	1.84 (0.80, 4.21)	0.152
	>9,641.00	2.02 (0.92, 4.44)	0.079	1.92 (0.793, 4.66)	0.148
BMI (*kg/m²*)	Underweight *(<18.5)*	1		1	
	Normal *(18.5–22.9)*	2.26 (1.07, 4.8)	0.033*	2.8 (1.22, 6.42)	0.015*
	Overweight or Obese *(≥23.0)*	2.39 (0.90, 6.31)	0.079	2.29 (0.77, 6.8)	0.134

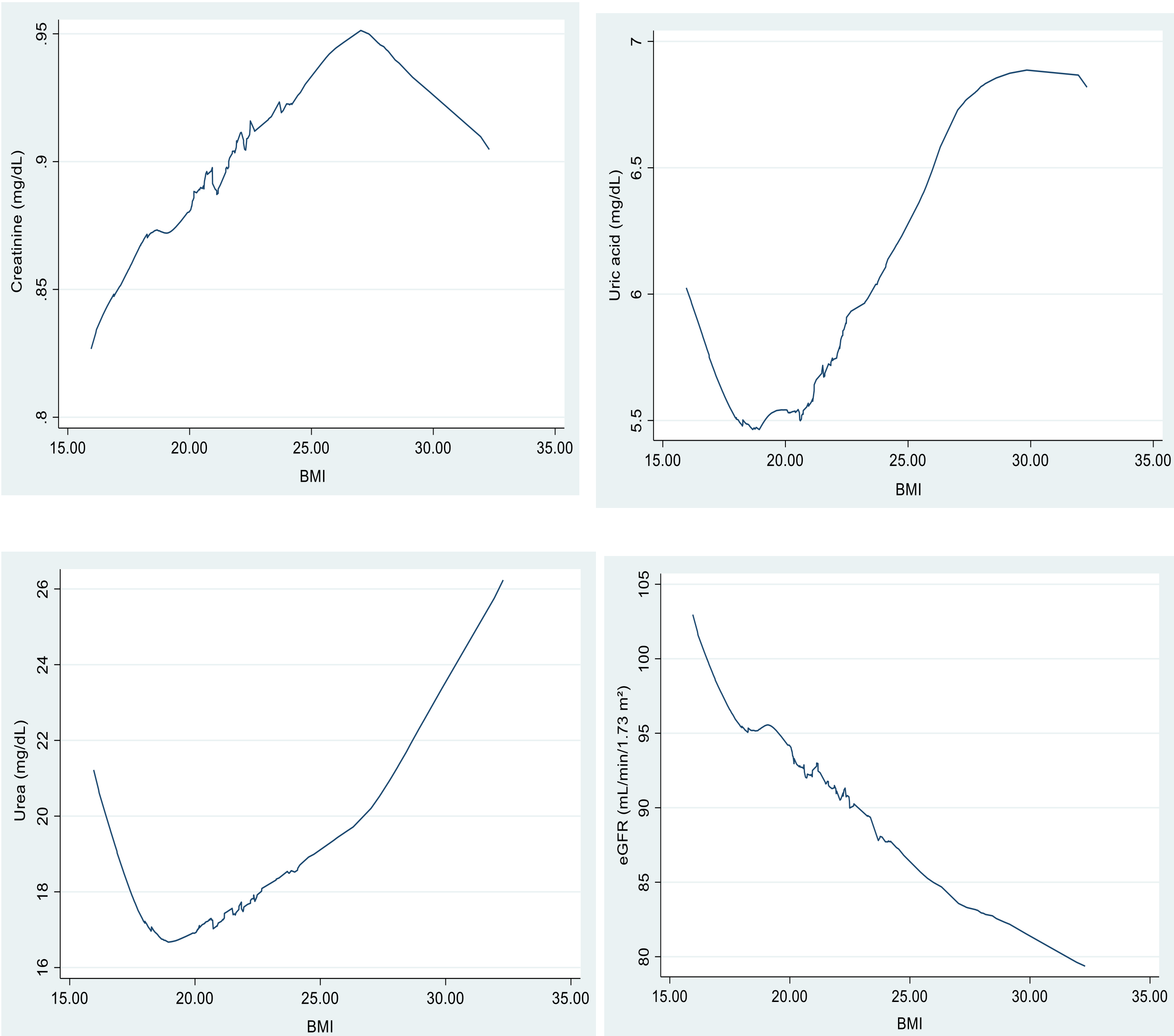

Figure 7: Smooth curves illustrating the association between BMI and kidney function parameters.

(7a) BMI vs. creatinine

(7b) BMI vs. uric acid

(7c) BMI vs. urea

(7d) BMI vs. eGFR

Figure 7 illustrates the non-linear association between BMI and kidney function markers. For creatinine, there is a positive relationship with BMI up to approximately 27.05 kg/m^2, after which the association becomes negative as BMI continues to increase. In the case of uric acid, a negative association is observed when BMI is around ≤ 20.6 kg/m^2, but as BMI rises, uric acid levels also increase. Similarly, for urea, a negative association is seen when BMI is approximately ≤ 19.0 kg/m^2, followed by an increase in urea levels as BMI increases. The smooth curve between eGFR and BMI showed a negative association between BMI and eGFR, indicating eGFR tends to decline with increasing BMI.

Chapter 5

Discussion

Discussion

This study goals to determine the association of socioeconomic conditions with serum urea, uric acid and creatinine among women of reproductive age in some selected areas of Bangladesh. It contributes to a well understanding of how social and economic factors affect renal health by revealing significant associations between these important kidney function markers and socioeconomic status. This study provides evidence that the majority of participants had normal levels of serum urea, uric acid and creatinine within normal ranges and also identifies several socioeconomic factors that were associated with those three kidney function markers. Particularly socioeconomic factors such as age, education, monthly expenditure on food and BMI of the reproductive age group women were significantly associated with abnormal serum urea, uric acid, and creatinine levels in Bangladesh. As the overweight prevalence growth rate is larger among individuals with less education and poor socioeconomic status, the social disparities constitute key risk factors for obesity-related chronic diseases in emerging nations [64].

The present study shows that 59.8% of the participants had normal levels of serum urea whereas uric acid and creatinine were 68.8% and 73.5%, respectively. Elevated levels were observed in 77 participants for urea (40.2%), 59 for uric acid (31.2%) and 50 for Creatinine (26.5%) when the average (mean ± SD) serum levels (mg/dl) were 5.74±2.05 for uric acid, 17.61±9.60 for urea and 0.89±0.27 for creatinine were similar to the studies of other countries for example, in northern Ethiopia, the mean values of serum uric acid, urea and creatinine were 4.43±0.15, 5.67±2.12, and 0.50±0.01 [65]. Furthermore, the mean values of serum uric acid, urea and creatinine were 3.86±0.92, 26.46±3.55, and 0.58±0.283 among normotensive women of Chennai in India [66]. A slight difference was observed because of the variation in the study population. In the study, as mentioned earlier, pregnant women were studied whereas our study population were healthy.

The study focuses on significant associations between socioeconomic factors - specifically age, education, monthly expenditure on food, and BMI—and elevated levels of serum urea, uric acid, and creatinine. Overweight or obese women had significantly higher mean serum urea, uric acid and serum creatinine levels ($p<0.05$) associated to those who were standard weight which is also consistent with existing literature [67]. Women from developing countries show an inverse association between socioeconomic status and elevated BMI as well as obesity [68, 69].

Serum urea and creatinine levels were higher in overweight and obese female adults, and both parameters were positively associated with BMI [70]. The normal blood or serum urea nitrogen level ranges from 5 to 20 mg/dL. Variations within this range are usually influenced by factors such as protein intake, internal protein breakdown, hydration levels, liver urea production, and kidney urea elimination [71]. Elevated urea levels affect organ function and the course of chronic renal disease by causing carboxylation, insulin resistance, reactive oxygen species (ROS) generation, and inflammation [72]. The highest concentration of urea is detected in the blood of uremic patients [73]. About one-third of the body's serum uric acid comes from dietary sources and the rest of them from endogenous sources. Elevated serum uric acid also shows accelerated purine degradation in high cell turnover states and reduced excretion from the kidney. The term hyperuricemia refers to an increased level of uric acid in the serum, often more than 5.8 mg/dl. in women due to increased uric acid synthesis, reduced excretion, or a combination of the two processes leading to hyperuricemia. A common consequence of hyperuricemia is gout, which is characterized by red, swollen joints that usually affect the big toe, and uric acid nephrolithiasis, which manifests as acute flank pain, hematuria, dysuria, nausea, and other urinary symptoms like fever and hazy urine and highly associated with acute kidney injury [74-76]. SUA was considerably higher in obese individuals than underweight individuals, and this elevation increased linearly with BMI which is about 2.98 times greater in overweight people and 5.96 times greater in obese people than in underweight people [77]. Assessing renal function can also predict the progression of kidney disease. The GFR (glomerular filtration rate) defines the flow rate of filtered fluid through the kidneys and serum creatinine is the most useful indicator for assessing GFR [78]. Chronic renal disease is defined by persistently increased blood creatinine levels and a significantly reduced GFR for more than three months. CKD damages numerous renal compartments and is caused by many disease processes [79]. Hypoxia is caused by a loss of microvasculature and increased fibrosis in the kidney, which results in acute kidney injuries, poor healing, and chronic damage characterized by tubular cell loss, collagen scars, and macrophage infiltration, eventually leading to progressive renal function decline and end-stage renal failure[80].

The study investigates the relationship between kidney function markers—serum urea, uric acid, and creatinine—and both nutritional status and socioeconomic factors within the general population. It also employed standardized laboratory methods for the estimation of kidney function markers. A quality control test was done repeatedly. The study was done by cross-sectional design which limits its capacity to establish causal relationships. As it was conducted in selected areas of Bangladesh, it may not fully represent the diversity of people. Though the sample size was adequate for finding associations, there may be selection bias as the women from selected areas do not represent all the reproductive age group women in Bangladesh. Sampling bias was present due to the unfortunate event of frozen sample spoilage and important confounders like dietary habits, and physical activity were not considered. While we adjusted for several potential confounders such as age, and monthly expenditure on food, education may also influence serum urea uric acid and creatinine.

Future research should focus on the controlling point of overweight and obesity of reproductive age group women such as promoting a balanced diet, behavioral changes, regular physical activity, environmental modifications to support healthy food choices, regular monitoring of weight and health status, awareness programs and advocate for policies that support healthy eating such as food labelling and addressing socioeconomic disparities are essential for improving renal health outcomes in this population. The study should be conducted on a large scale nationwide to incorporate cultural diversity in socioeconomic status among women of reproductive age in Bangladesh.

Strengths and limitations:

This study offers valuable insights into the relationship between kidney function markers (serum urea, uric acid, and creatinine) and BMI, as well as socioeconomic conditions, among WRA in Bangladesh. One of the major strengths lies in the use of standardized laboratory methods for biomarker analysis, along with repeated quality control assessments to ensure data accuracy and reliability.

However, the study's cross-sectional design restricts its ability to determine causal relationships. Furthermore, important confounding factors such as nutritional intake, hydration status, and physical activity were not included in the analysis. Although adjustments were made for several variables including age, education, and monthly food expenditure; other unmeasured factors may also influence kidney function markers and should be considered in future research. Additionally, future research should explore the association of kidney function markers

Conclusion

The present study found that only one-third of women of reproductive age (WRA) had normal levels of all three key kidney function markers—serum creatinine, urea, and uric acid. A significant proportion of participants exhibited elevated levels of these markers, indicating an underlying risk for kidney dysfunction among this population. Importantly, the study found that body mass index (BMI) was significantly associated with the risk of elevated kidney function markers, even after adjusting for other related factors. This underscores the complex relationship between nutritional status and renal health in WRA.

The study also provides a rare and valuable insight into the biochemical profile of kidney function among WRA in Bangladesh, aged 17 to 49 years, and their association with both nutritional and socioeconomic variables. Notably, while global literature has acknowledged the influence of nutrition and socioeconomic status on kidney function, there is a scarcity of such data specifically for Bangladeshi women. Existing national-level studies rarely explore all three markers (serum creatinine, urea, and uric acid) in conjunction, nor do they analyze them alongside socioeconomic and nutritional indicators in women of reproductive age or the general population. This study, therefore, helps to fill a critical research gap in the local context.

The findings highlight an urgent public health concern regarding the potential burden of kidney dysfunction in WRA and the broader implications this holds for maternal and family health. Given that these women often represent the foundation of family and community health, undiagnosed or unmanaged kidney dysfunction can have far-reaching consequences, including pregnancy complications, poor maternal outcomes, and intergenerational impacts on child health.

These findings call for the integration of routine kidney function assessments into existing maternal and women's health programs. Additionally, interventions should be designed to improve nutritional status and address the broader socioeconomic determinants of health. The results serve as a strong justification for policymakers and healthcare planners to take proactive steps toward early detection and prevention of kidney-related health problems in this vulnerable group.

Finally, the study highlights the need for further research involving a larger and more representative sample to confirm these findings and gain a deeper understanding of the underlying mechanisms. Such data are essential for developing effective, evidence-based health policies and strategies. Collaborative efforts involving healthcare providers, public health professionals, and government bodies will be vital in addressing this emerging issue and safeguarding the health and well-being of women across Bangladesh.

Recommendation:

1. **Implement routine screening for kidney function markers in women**: Given the high prevalence of abnormal serum creatinine, urea, and uric acid levels observed in the study, regular screening programs should be established for women of reproductive age. Early detection through community-based or primary healthcare services can help identify at risk individuals and prevent the progression to chronic kidney disease.
2. **Promote nutritional interventions to address both underweight and overweight:** Since BMI was significantly associated with kidney function abnormalities, nutritional programs should aim to improve overall nutritional status by targeting both under nutrition and overweight/obesity. Tailored dietary counseling and public health nutrition campaigns can help maintain optimal body weight and reduce kidney health risks.
3. **Raise awareness about kidney health in women:** Public health education initiatives should emphasis on increasing awareness among women about the importance of kidney function, risk factors for kidney disease, and the long-term health consequences of unmanaged abnormalities. Culturally sensitive educational materials and outreach in rural areas can support this goal.
4. **Integrate socioeconomic support with health programs**: Since socioeconomic status is likely linked to kidney function outcomes, health interventions should be complemented by programs that address poverty, access to education, and economic empowerment for

women. Intersectional collaboration between health, education, and social welfare ministries is recommended.

5. **Enhance healthcare access in underserved regions**: The study highlights the need to strengthen healthcare infrastructure in rural and remote areas where many women may lack access to diagnostic and preventive services. Mobile health units, trained community health workers, and improved referral systems can help bridge the gap.
6. **Conduct further large-scale research:** To generalize the findings and explore causal relationships more thoroughly, larger studies with diverse populations across Bangladesh are needed. Future research should also consider longitudinal designs to examine changes in kidney function over time and their association with lifestyle and socioeconomic trends.

Chapter 6

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