

Chronic Kidney Disease among Marginalized Agricultural Communities: Evidence from a Field Survey in the Uddanam Region of Andhra Pradesh, India

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Abstract

Chronic Kidney Disease (CKD) of unknown etiology has emerged as a significant public health crisis in the Uddanam region of Srikakulam District, Andhra Pradesh, India. This study presents findings from a field-based survey conducted among marginalized agricultural communities to assess the demographic, clinical, and socio-economic dimensions of CKD. A total of 942 CKD patients were sampled across seven mandals between February and April 2023. The results indicate a high prevalence among male agricultural workers (71%), with 81.8% of patients aged above 45 years. Most patients were in stages II and III of CKD, indicating delayed diagnosis and limited access to preventive care. Despite government interventions such as the YSR Sujaladhara drinking water project, only 13.3% of patients reported direct benefits from welfare schemes. The study highlights the urgent need for early-stage treatment, awareness programs, and improved financial support for patients. The findings contribute to the growing literature on CKD in agricultural regions and underscore the importance of social determinants in disease prevalence.

Keywords: Chronic Kidney Disease, Uddanam, marginalized communities, agricultural health, public health policy, India

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1. Introduction

Chronic Kidney Disease (CKD) has emerged as one of the most significant non-communicable diseases of the 21st century, with far-reaching implications for global health systems, economic productivity, and social equity. Recent global burden estimates indicate that nearly **10% of the world's population** is affected by some form of CKD, making it a silent epidemic that often progresses unnoticed until advanced stages. CKD is now recognized as a major contributor to **premature mortality, disability-adjusted life years (DALYs), and healthcare expenditure**, particularly in low- and middle-income countries where access to early diagnosis and renal replacement therapy remains limited [1]. The disease imposes a dual burden: direct medical costs associated with dialysis and transplantation, and indirect costs arising from loss of productivity, impoverishment, and social marginalization of affected households.

In the past two decades, researchers have identified a distinct form of CKD that does not follow the traditional etiological pathways associated with diabetes, hypertension, or glomerular diseases. This condition, widely referred to as **Chronic Kidney Disease of unknown etiology (CKDu)**, has been reported in several geographically and climatically similar agricultural regions across the world. Notable hotspots include **Central America (particularly Nicaragua and El Salvador), Sri Lanka's North Central Province, and parts of India,**

especially in Andhra Pradesh and Odisha [2][3]. The emergence of CKDu has raised serious public health concerns because it predominantly affects **young and middle-aged agricultural workers**, often in economically disadvantaged communities, leading to severe social and economic consequences.

Within India, the **Uddanam region** of Srikakulam district in Andhra Pradesh has drawn both national and international attention due to an unusually high prevalence of CKD among farming populations. The region, characterized by extensive cashew and coconut cultivation, has reported thousands of CKD cases over the past two decades, with a significant proportion lacking traditional risk factors such as diabetes or long-standing hypertension [4]. Epidemiological investigations have revealed patterns similar to other CKDu-endemic regions, including concentration among rural male laborers, delayed diagnosis, and high mortality rates.

Unlike conventional CKD, which is primarily attributed to metabolic and lifestyle-related conditions, CKDu in Uddanam is believed to arise from a **complex interplay of environmental, occupational, and socio-economic determinants** [5]. The absence of a single identifiable cause has made it difficult to design targeted interventions, and the disease is increasingly viewed through the lens of **environmental justice and social determinants of health.**

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Multiple studies have suggested potential risk factors contributing to the development of CKDu in agricultural communities:

- **Groundwater contamination:**

Several investigations have reported elevated levels of heavy metals, silica, and other nephrotoxic substances in groundwater sources used for drinking and irrigation. Long-term consumption of such water is believed to cause gradual kidney damage [6].

- **Pesticide and agrochemical exposure:** Farmers in affected regions are frequently exposed to herbicides, insecticides, and fertilizers, often without adequate protective equipment. Chronic exposure to these chemicals may contribute to renal toxicity.

- **Heat stress and recurrent dehydration:** Agricultural labor in tropical climates involves prolonged exposure to high temperatures. Repeated episodes of dehydration, coupled with strenuous physical activity, are believed to cause subclinical kidney injury that progresses over time [7].

- **Socioeconomic deprivation:** Poor living conditions, inadequate nutrition, limited access to healthcare, and low awareness about early symptoms contribute to delayed diagnosis and poor disease outcomes.

In response to the growing crisis, the Government of Andhra Pradesh has implemented several interventions, including the establishment of specialized kidney care facilities, dialysis centers, and large-scale drinking water supply projects such as the **YSR Sujaladhara Uddanam Drinking Water Scheme**. These initiatives aim to reduce exposure to potentially contaminated groundwater and improve access to treatment. However, despite these efforts, CKD continues to disproportionately affect marginalized farmers, indicating persistent structural, environmental, and healthcare access challenges.

Against this backdrop, the present study seeks to provide **updated empirical evidence from a field-based survey conducted in 2023** across several mandals in the Uddanam region. By examining demographic patterns, disease stages, and access to welfare schemes, the study aims to contribute to a deeper understanding of CKD among marginalized agricultural communities and to inform more effective policy interventions.

2. Study Area: Uddanam Region

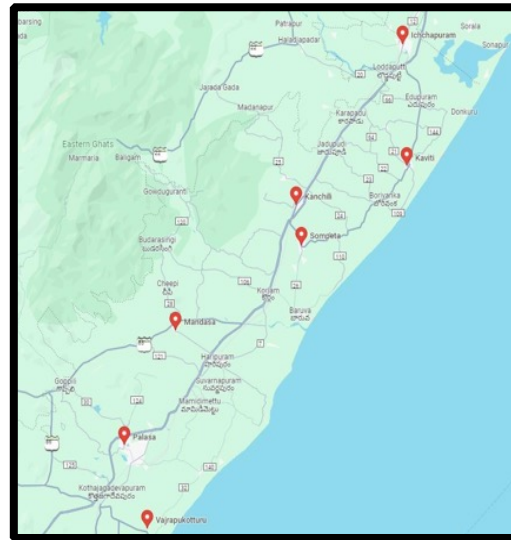


Figure 1: Map showing surveyed mandals in the Uddanam region.

The present study was conducted in the **Uddanam region** of Srikakulam district, located in the northernmost part of Andhra Pradesh, India. Uddanam is a coastal belt situated along the Bay of Bengal and shares a border with the state of Odisha. The region is characterized by tropical climatic conditions, sandy and lateritic soils, and a predominantly rural settlement pattern. Agriculture constitutes the primary source of livelihood, with most households depending on small and marginal farming or agricultural wage labor.

Over the past two decades, Uddanam has drawn significant attention from public health researchers, policymakers, and the media due to the unusually high prevalence of Chronic Kidney Disease (CKD), particularly among agricultural workers. The region is often described as one of the **CKD hotspots in India**, comparable to other CKDu-affected areas globally. The concentration of cases in this region has raised concerns about environmental exposures, occupational risks, and socio-economic vulnerabilities that may be contributing to the disease burden.

The survey was conducted across seven mandals within the Uddanam belt, namely:

- Palasa
- Ichapuram
- Kanchili
- Sompeta
- Kaviti
- Mandasa
- Vajrapu Kotturu

These mandals were selected because of their reported high CKD prevalence and the presence of healthcare facilities catering to renal patients, such as government hospitals, dialysis centers, and specialized kidney research institutions.

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The region is predominantly agrarian, with **cashew and coconut cultivation** forming the backbone of the local economy. A significant proportion of the population is engaged in farming, plantation work, or agricultural labor under harsh climatic conditions. Agricultural practices in the region often involve intensive use of fertilizers, pesticides, and groundwater for irrigation. Many farmers rely on borewells and local groundwater sources for drinking and farming, which has been a major concern in studies examining environmental contributors to CKD.

Socioeconomically, the population in these mandals largely comprises **marginalized and backward communities**, including smallholder farmers, tenant cultivators, and daily wage laborers. Limited access to quality healthcare, financial constraints, and lack of awareness about early symptoms of kidney disease have historically contributed to delayed diagnosis and poor treatment outcomes.

The geographical spread of CKD cases across multiple mandals indicates that the problem is not confined to isolated pockets but represents a broader regional public health challenge. The presence of dedicated kidney care facilities, including government hospitals and dialysis centers in Palasa and Haripuram, reflects the scale of the issue and the government's response to it. However, the continued prevalence of CKD suggests the need for more comprehensive and preventive approaches.



Figure 2: Glimpses of the Survey at Uddanam Region

3. Methodology

3.1 Study Design

The present study adopted a **cross-sectional field survey design** to assess the demographic, clinical, and socio-economic characteristics of chronic kidney disease (CKD) patients in the Uddanam region. A cross-sectional approach was considered appropriate because it allows for the assessment of disease patterns, distribution, and associated factors at a specific point in time. Such designs are widely used in epidemiological research, particularly in resource-constrained settings, to generate baseline data for policy formulation and public health interventions.

The field survey was conducted in two phases:

- **14–15 February 2023**

- **19–21 April 2023**

These periods were selected to ensure adequate field coverage across multiple mandals and to allow sufficient interaction with patients, healthcare providers, and local communities. The survey was carried out by scholars, students, and volunteers associated with the Dr. B.R. Ambedkar Chair, who were trained in basic data collection procedures and ethical engagement with participants. The primary objective of the cross-sectional survey was to document the **prevalence patterns, disease stages, demographic characteristics, and access to welfare schemes** among CKD patients in the affected mandals.

3.2 Sample

The study covered a total of **942 CKD patients** drawn from the selected mandals in the Uddanam region. The sample size was considered sufficiently large to represent the affected population across multiple villages and to provide meaningful statistical insights into disease distribution.

A **random and uniform sampling approach** was adopted to minimize selection bias and ensure that patients from different mandals, age groups, and socio-economic backgrounds were included. Patients were identified through:

- Local health records
- Dialysis centers
- Government hospitals
- Community-level referrals

The **target population** consisted primarily of CKD patients belonging to **marginalized agricultural communities**, including small and marginal farmers, plantation workers, and daily wage laborers. These groups were selected because previous studies and government reports have indicated a disproportionately high burden of CKD among them.

3.3 Data Collection

Data collection was carried out using a **mixed-method approach**, combining quantitative and qualitative techniques to ensure comprehensive understanding of the disease and its socio-economic implications.

The following tools and sources were used:

1. **Structured Questionnaires**
 - Standardized questionnaires were administered to collect demographic, occupational, and socio-economic data.
 - Questions covered age, gender, occupation, income levels, treatment history, and awareness about CKD.
2. **Clinical Records**

- Available medical records were reviewed to obtain clinical parameters such as CKD stage and creatinine levels.
- Data from hospitals, dialysis centers, and local health units were used wherever accessible.

3. Interviews with Patients and Families

- Semi-structured interviews were conducted with patients and their family members.
- These interactions provided insights into treatment challenges, financial burdens, access to welfare schemes, and perceptions of the disease.

The involvement of trained scholars and volunteers ensured systematic data collection while maintaining sensitivity to the social and emotional conditions of the patients.

3.4 Variables

The study focused on a set of **key demographic, clinical, and socio-economic variables** that are commonly used in CKD epidemiological research. These variables were selected to understand both the medical and social dimensions of the disease.

The primary variables included:

- **Age:**
To examine the age-wise distribution of CKD and identify vulnerable age groups.
- **Gender:**
To assess differences in disease prevalence between male and female patients.
- **CKD Stage:**
To determine the severity and progression of the disease among surveyed patients.
- **Creatinine Levels:**

As a key biochemical indicator of kidney function, used to assess disease severity.

- **Access to Welfare Schemes:**
To evaluate the extent to which government support systems were reaching affected patients.
- **Treatment Status:**
To understand the proportion of patients receiving medication, dialysis, or other forms of care.

These variables enabled a comprehensive analysis of CKD prevalence, disease progression, and socio-economic impacts in the Uddanam region. The collected data formed the basis for statistical analysis, graphical representation, and policy-oriented recommendations presented in subsequent sections of the study.

4. Results

This section presents the major findings of the field survey conducted among 942 CKD patients across the selected mandals in the Uddanam region. The results are organized according to demographic, clinical, and socio-economic indicators to provide a comprehensive understanding of disease distribution and patient conditions.

4.1 Gender Distribution

The survey revealed a **significant gender disparity** among CKD patients. Out of the total 942 respondents:

- **Male patients:** 669 (71%)
- **Female patients:** 273 (29%)

The predominance of male patients suggests a strong occupational linkage, as men in the region are more likely to be engaged in intensive agricultural labor. Prolonged exposure to heat, dehydration, agrochemicals, and other occupational hazards may increase the risk of kidney damage. Similar patterns have been reported in CKDu-affected regions in Central America and Sri Lanka, where male agricultural workers constitute the majority of cases. The gender imbalance also reflects socio-cultural and economic dynamics in rural areas, where men are more exposed to physically demanding fieldwork, while women often perform domestic or less hazardous agricultural tasks. However, the presence of a substantial proportion of female patients indicates that CKD is not limited to occupational exposure alone and may involve environmental and household-level risk factors.

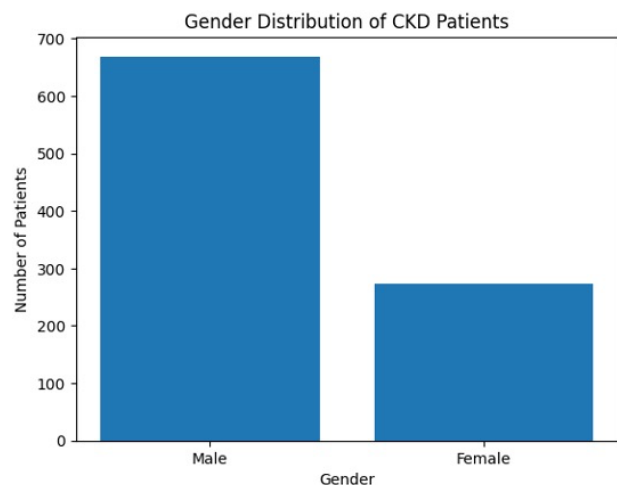


Figure 3: Gender distribution of CKD patients (bar chart)

4.2 Age Distribution

The age-wise analysis shows that CKD in the Uddanam region is largely concentrated among the middle-aged and elderly population.

- **Patients above 45 years:** 81.8%
- **Patients below 45 years:** 18.2%

This distribution indicates that CKD is more prevalent among individuals with prolonged exposure to environmental and occupational risk factors. The higher

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concentration of cases among older age groups may reflect the cumulative impact of years of agricultural labor, consumption of potentially contaminated water, and limited access to early healthcare.

Interestingly, the relatively lower proportion of patients below 45 years may suggest a **declining trend among younger populations**, possibly due to recent government interventions such as improved drinking water supply and increased awareness about CKD. However, the presence of nearly one-fifth of patients in the younger age group still raises concerns about ongoing exposure to risk factors.

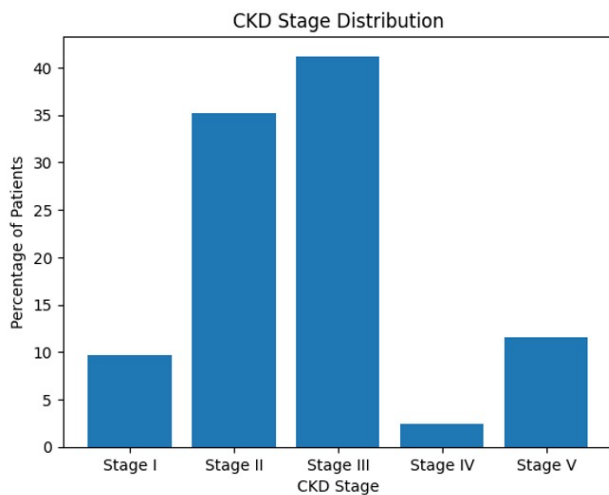


Figure 4: Age-wise distribution of CKD patients (pie chart).

4.3 CKD Stage Distribution

The distribution of patients across different CKD stages provides insight into the severity and progression of the disease within the community.

CKD Stage	Percentage
Stage I	9.7%
Stage II	35.15%
Stage III	41.21%
Stage IV	2.42%
Stage V	11.52%

A majority of patients were found in **Stages II and III**, which together account for more than three-quarters of the surveyed population. This pattern suggests that many patients are diagnosed only after the disease has progressed beyond the earliest stage. The relatively low percentage in Stage I indicates limited early detection and screening.

The presence of 11.52% of patients in Stage V highlights the **severe burden of end-stage renal disease**, which typically requires dialysis or kidney transplantation. Given the high costs and limited accessibility of such treatments, this stage poses significant economic and social challenges for affected households.

Overall, the stage distribution underscores the need for:

- Early screening programs
- Improved primary healthcare services
- Timely intervention strategies

Age Distribution of CKD Patients

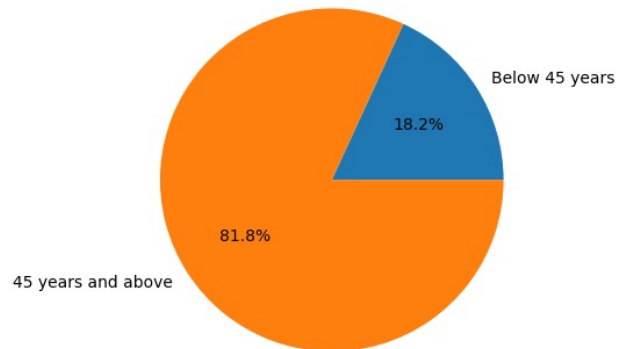


Figure 5: CKD stage distribution (stacked bar chart)

4.4 Creatinine Levels

Creatinine levels among the surveyed patients ranged from:

- **Minimum:** 0.9 mg/dL
- **Maximum:** 10 mg/dL

This wide range reflects the varying degrees of kidney function impairment among patients. Some individuals exhibited relatively controlled creatinine levels, while others showed severely elevated values indicative of advanced kidney failure.

An important observation from the survey is that **controlled or moderate creatinine levels do not necessarily guarantee sustained health**. Several patients with seemingly manageable creatinine levels reported symptoms, complications, or progression of the disease.

This finding highlights the importance of:

- Continuous monitoring
- Comprehensive clinical assessment
- Early therapeutic intervention

It also suggests that reliance on a single biochemical indicator may not provide a complete picture of kidney health, particularly in CKDu-affected populations.

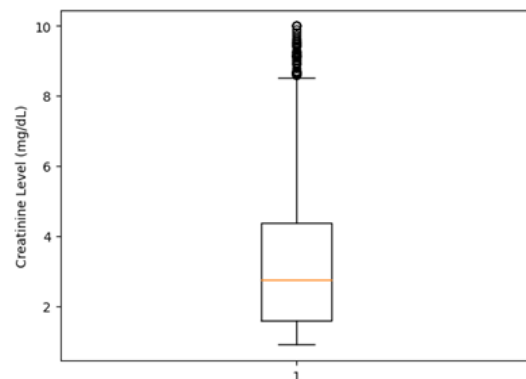


Figure 6: Box plot showing creatinine level distribution

4.5 Welfare Scheme Access

Access to government welfare schemes among CKD patients was found to be significantly limited.

- **Beneficiaries:** 13.3%
- **Non-beneficiaries:** 86.7%

Despite the existence of several government initiatives aimed at supporting CKD patients, only a small proportion of respondents reported receiving direct benefits. This indicates gaps in:

- Awareness about available schemes
- Administrative processes
- Accessibility of services
- Geographic and financial barriers

The low level of welfare access places an additional financial burden on patients and their families, many of whom belong to economically vulnerable agricultural communities. The costs associated with travel, medication, dialysis, and loss of income further exacerbate their socio-economic hardships.

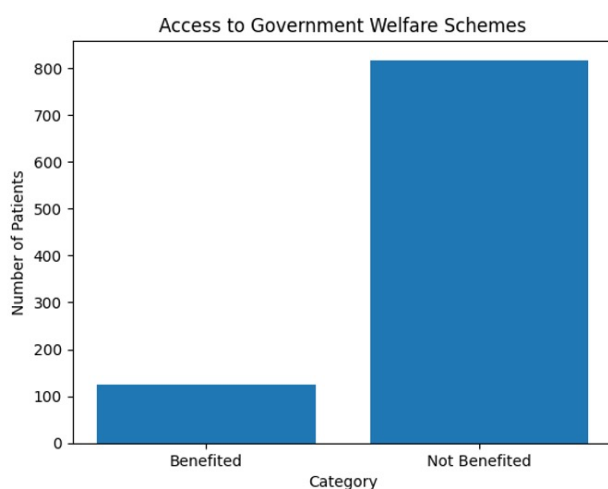


Figure 7: Access to government welfare schemes.

Summary of Key Findings

The results indicate that CKD in the Uddanam region:

- Predominantly affects male agricultural workers.
- Is concentrated among individuals above 45 years.
- Is most commonly detected in intermediate stages (II and III).
- Shows wide variation in creatinine levels.
- Is associated with limited access to welfare support.

These findings highlight the need for targeted interventions focusing on early detection, improved healthcare access, and enhanced social support mechanisms for affected communities.

5. Discussion

The findings of the present survey provide important insights into the demographic, clinical, and socio-economic dimensions of Chronic Kidney Disease (CKD) in the Uddanam region. When viewed in the context of national and global CKDu research, the results reveal patterns consistent with other agricultural hotspots, while also highlighting region-specific challenges related to healthcare access and welfare delivery.

5.1 Demographic Patterns

One of the most striking observations in the survey is the **predominance of male patients**, who constitute 71% of the total sample. This gender imbalance is closely linked to the occupational structure of the region. In Uddanam, as in many rural agricultural economies, men are primarily engaged in **physically intensive fieldwork**, including land preparation, pesticide application, irrigation, and harvesting. These activities often involve:

- Prolonged exposure to high temperatures
- Repeated episodes of dehydration
- Direct contact with agrochemicals
- Consumption of untreated groundwater in the fields

Such occupational exposures have been identified as key risk factors in CKDu-affected regions worldwide. Similar gender patterns have been reported in **Sri Lanka's North Central Province and the Mesoamerican region**, where male agricultural workers represent the majority of CKDu cases [2][8]. This suggests that the disease may be closely associated with occupational and environmental stressors rather than purely biological factors.

The **age distribution** further reinforces this interpretation. The survey found that 81.8% of patients were above the age of 45, indicating that CKD prevalence increases with age. This trend is likely the result of **cumulative exposure** to environmental toxins, occupational stress, and poor-quality drinking water over many years. The chronic nature of these exposures leads to gradual kidney damage, which often remains asymptomatic until the disease reaches intermediate or advanced stages.

The concentration of cases among older individuals also reflects limited access to preventive healthcare and screening services, which could otherwise detect the disease at earlier stages.

5.2 CKD Stage Distribution

The stage-wise distribution of CKD patients reveals that a majority are concentrated in **Stages II and III**, which together account for more than three-quarters of the surveyed population. This pattern suggests that many patients are diagnosed only after the disease has progressed beyond its earliest stage.

The low proportion of Stage I cases (9.7%) indicates significant gaps in:

- Early detection mechanisms
- Routine screening programs
- Community-level awareness
- Primary healthcare outreach

In many rural areas, CKD symptoms remain unnoticed or are misinterpreted until the disease advances. Limited availability of diagnostic facilities and specialist care further delays detection.

This stage distribution also points to **inadequate primary healthcare infrastructure**, particularly in remote and economically disadvantaged regions. Primary health centers often lack:

- Diagnostic equipment for kidney function tests
- Trained nephrology personnel
- Regular screening programs for at-risk populations

Similar patterns have been observed in other CKDu hotspots, where **early-stage diagnosis is uncommon**, and patients typically present at intermediate or advanced stages [9]. This trend underscores the need for systematic screening initiatives and improved primary healthcare services in the Uddanam region.

5.3 Impact of Drinking Water Interventions

An encouraging observation from the survey is the relatively lower proportion of younger patients, with only 18.2% of cases occurring among individuals below 45 years of age. This trend may indicate a **possible positive impact of recent drinking water interventions**, particularly the **YSR Sujaladhara Uddanam Drinking Water Project**.

The project was initiated to provide **safe, treated drinking water** to CKD-affected villages, thereby reducing dependence on potentially contaminated groundwater sources. Several earlier studies have identified **groundwater contamination**, including the presence of heavy metals, silica, and agrochemical residues, as a possible contributing factor to CKDu [6][10].

The lower prevalence among younger age groups may reflect:

- Reduced exposure to contaminated water
- Increased awareness about safe drinking practices
- Improved access to treated water sources

However, it is important to note that this observation is **indicative rather than conclusive**. Longitudinal studies and environmental monitoring are required to establish a definitive causal relationship between drinking water interventions and declining CKD incidence among younger populations.

5.4 Socioeconomic Barriers

One of the most concerning findings of the survey is the **limited access to government welfare schemes**. Only 13.3% of patients reported receiving benefits, while the overwhelming majority (86.7%) had not accessed any form of financial or institutional support.

This low level of welfare access suggests the presence of multiple systemic barriers, including:

- **Administrative complexities:** Lengthy procedures and documentation requirements may discourage patients from applying.
- **Lack of awareness:** Many patients and their families may not be fully informed about available schemes.
- **Geographical constraints:** Remote villages and poor transport infrastructure limit access to welfare offices and healthcare facilities.
- **Institutional bottlenecks:** Delays in approval and disbursement of benefits.

Financial hardship is a critical issue in CKD-affected communities. Most patients belong to **economically vulnerable agricultural households**, where income is irregular and heavily dependent on seasonal farming. The cost of CKD treatment—including medication, travel, dialysis, and loss of working days—places a significant burden on families.

Long travel distances to dialysis centers or specialized hospitals further exacerbate the problem. Patients often have to travel several kilometers multiple times a week, leading to:

- Increased transportation costs
- Physical strain on already weakened patients
- Loss of wages for both patients and caregivers

Similar challenges have been documented in other CKD-affected regions, where the **economic burden of treatment** is a major factor contributing to poor health outcomes and increased mortality [11].

Overall Implications

The discussion highlights that CKD in the Uddanam region is not merely a biomedical issue but a **multidimensional public health challenge** shaped by occupational risks, environmental exposures, healthcare infrastructure gaps, and socio-economic inequalities.

The findings emphasize the need for:

- Occupational health interventions
- Early screening and detection programs
- Safe drinking water initiatives
- Simplified and accessible welfare mechanisms

Addressing CKD in such contexts requires an integrated approach that combines **medical, environmental, and socio-economic strategies** to reduce both disease incidence and its long-term impacts on marginalized communities.

6. Policy Implications

The findings of the present study reveal that CKD in the Uddanam region is not only a medical concern but also a **social and economic challenge** affecting marginalized agricultural communities. The high concentration of patients in intermediate stages, limited access to welfare schemes, and the financial burden associated with treatment indicate the need for **comprehensive and targeted policy interventions**. Based on the survey results, the following policy measures are recommended.

6.1 Early Detection

Early detection is critical in preventing the progression of CKD to advanced stages, where treatment becomes more expensive and less effective. The survey results show a low proportion of patients in Stage I, indicating that many cases are diagnosed only after significant kidney damage has occurred.

To address this issue, the following measures are essential:

- **Community-level screening programs:** Regular screening camps should be organized in villages, especially in high-risk agricultural areas. These programs can include basic kidney function tests such as serum creatinine and urine analysis. Screening should focus on vulnerable groups, including farmers, agricultural laborers, and individuals above 35–40 years of age.
- **Mobile health units:** Mobile medical units equipped with diagnostic facilities can reach remote and underserved villages. These units can conduct periodic screening, provide basic treatment, and refer patients to higher-level healthcare facilities when necessary. Such initiatives can significantly reduce the delay in diagnosis and improve treatment outcomes.

Early detection policies will help shift the focus from expensive tertiary care to **preventive and primary healthcare**, thereby reducing the overall burden on both patients and the healthcare system.

6.2 Free Early-Stage Medication

The survey revealed that **51.75% of patients demanded access to advanced medication during the early stages** of CKD. This indicates a significant gap in treatment availability at the primary and secondary healthcare levels. Providing **free or subsidized medication for early-stage CKD** can:

- Slow disease progression
- Reduce the need for dialysis or transplantation
- Lower long-term healthcare costs
- Improve quality of life for patients

Government policies should ensure the **regular supply of essential nephrology drugs** at primary health centers, community health centers, and district hospitals. Integrating CKD treatment into existing public health programs can also improve accessibility and continuity of care.

6.3 Awareness Programs

A significant proportion of respondents (45.61%) emphasized the need for **CKD awareness initiatives**. Lack of awareness about early symptoms, risk factors, and preventive measures contributes to delayed diagnosis and poor treatment outcomes.

Effective awareness programs should include:

- **Village-level health education campaigns** on CKD symptoms and prevention.
- Training of **local health workers, ASHA workers, and community volunteers** to identify early signs and guide patients to appropriate healthcare facilities.
- Distribution of informational materials in local languages.
- Use of local media, community meetings, and schools to spread awareness.

Awareness initiatives can encourage behavioral changes such as:

- Drinking safe, treated water
- Reducing exposure to harmful agrochemicals
- Seeking early medical consultation

These measures can significantly reduce the incidence and severity of CKD over time.

6.4 Financial Support

The financial burden of CKD treatment is a major concern for affected households. Most patients belong to economically vulnerable farming communities, where income is uncertain and healthcare expenses can be catastrophic.

The study highlights the need for:

- **Travel subsidies:** Many patients must travel long distances to dialysis centers and specialized hospitals. Providing transportation allowances or free travel facilities can reduce this burden.
- **Income support schemes:** CKD often leads to loss of working capacity, affecting household income. Direct financial assistance, disability pensions, or livelihood support programs can help families cope with the economic impact.

- **Simplified welfare access:**

Streamlining application procedures and improving awareness about existing schemes can increase the number of beneficiaries.

Financial support measures will not only improve treatment adherence but also prevent affected families from falling deeper into poverty.

- **Overall Policy Direction**

The policy implications of this study emphasize the need for a **multi-dimensional approach** that combines early detection, accessible treatment, awareness, and socio-economic support. Such integrated strategies are essential to reduce the CKD burden in the Uddanam region and improve the health and well-being of marginalized agricultural communities.

7. Conclusion

This field-based study confirms the **persistent and uneven burden of Chronic Kidney Disease (CKD)** among marginalized agricultural communities in the Uddanam region. The findings show that the disease disproportionately affects **older male farmers**, reflecting long-term occupational exposure and socio-environmental risk factors. A large proportion of patients were found in **intermediate stages of CKD**, indicating delayed diagnosis and limited access to early screening services.

Although recent government interventions, particularly safe drinking water initiatives, appear to have contributed to a **reduction in cases among younger populations**, the overall burden of the disease remains significant. The study also highlights the **limited reach of welfare schemes**, with only a small proportion of patients receiving direct benefits. This indicates the need for more effective implementation, awareness, and accessibility of support mechanisms.

To reduce the CKD burden in the region, **comprehensive and integrated strategies** are essential. These should focus on early detection, free or subsidized medication at initial stages, community awareness programs, and financial assistance for affected households. Such measures can improve treatment outcomes and enhance the quality of life for vulnerable populations.

8. Limitations

The study has certain limitations that should be considered while interpreting the findings:

- **Cross-sectional design:** The study provides a snapshot of the CKD situation at a specific point in time and does not capture changes in disease progression or incidence over time.
- **Lack of longitudinal clinical data:**

The absence of long-term patient follow-up limits the ability to analyze disease progression, treatment outcomes, and causal relationships.

- **Dependence on self-reported welfare access:** Information regarding welfare benefits was based on patient responses, which may be influenced by recall bias or lack of awareness about available schemes.

9. Future Research Directions

The findings of this study point to several important areas for future research:

- **Longitudinal studies on environmental exposure:** Long-term monitoring of patients and environmental factors such as water quality, agrochemical exposure, and occupational stress can help identify causal relationships.
- **Biomarker-based early detection models:** Research on novel biomarkers and predictive models can enable earlier diagnosis of CKD, particularly in high-risk agricultural populations.
- **Evaluation of water intervention projects:** Systematic assessment of drinking water initiatives, such as the YSR Sujaladhara project, can help determine their effectiveness in reducing CKD incidence and guide future policy decisions.

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