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# Silent Epidemic: Chronic Kidney Disease Prevalence and Trends in Himachal Pradesh, India

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## Abstract

**Background:** This study examined the rising incidence and prevalence of Chronic Kidney Disease (CKD) across age, gender, and regions in Himachal Pradesh to inform targeted public health strategies.

**Methods:** CKD incidence data were collected from various age groups, gender, and blocks. Statistical analyses, including chi-square tests, were used to assess the significance of differences in CKD case distribution by age, gender, temporal and region.

**Results:** The significant spatial, temporal, gender, and age-related variations in Chronic Kidney Disease (CKD) prevalence across Himachal Pradesh (2014–2023), with Shimla showing the highest prevalence. CKD disproportionately affects male (60.2%) Mashobra (20.4%) reports the highest CKD cases, followed by Theog (12.3%), and Kupvi (2.4%) the lowest. Significant gender differences across blocks are confirmed ($\chi^2 = 26.436$, $p < .01$). Chi-square analysis ($\chi^2 = 18.423$, $p < .05$) revealed significant gender disparities in CKD cases from 2014 to 2023, with peaks in 2023 (16.9%) and a low in 2017 (6%). Chi-square analysis ($\chi^2 = 41.076$, $p < .000$) showed a significant age-gender association in CKD, with the highest number of cases in 57–67 years (637) and lowest in <17 years (12). Chi-square analysis ($\chi^2 = 124.625$, $p < .000$) revealed significant age-year associations in CKD cases, with peaks in 2023 (441 cases), predominantly among 57–67 years (117 cases).

**Conclusion:** The present study targeted interventions addressing spatial, gender, and age disparities in CKD, alongside enhanced screening and prevention, are crucial to reducing the disease burden and improving public health in Himachal Pradesh.

**Keywords:** chronic kidney disease incidence; spatial variations; temporal trends; gender disparities; age-related patterns

## Introduction

Chronic Kidney Disease (CKD) has emerged as a significant global health challenge, often described as a "silent epidemic" due to its asymptomatic progression in the early stages. CKD is characterized by a gradual decline in kidney function, leading to severe health complications such as cardiovascular diseases, kidney failure, and increased mortality [1]. CKD affects an estimated 10-15 percent of the global population, yet it remains underdiagnosed and inadequately addressed, particularly in low-and middle-income countries [2, 3]. In India, CKD poses a significant public health challenge, with a reported prevalence of 17.2% in rural areas, underscoring disparities in disease burden and healthcare access [4]. The rising incidence demands urgent intervention to mitigate its profound health and economic consequences [5].

Keeping in view, the observing temporal trends in CKD prevalence is vital for understanding disease dynamics, evaluating healthcare interventions, and shaping public health policies. Trends reveal shifts in disease burden, emerging risk factors, and the efficacy of interventions [6]. For example, rising CKD cases among younger populations may signal the influence of lifestyle-related factors like obesity and hypertension [1]. Temporal insights guide region-specific strategies, including enhanced nephrology infrastructure, behavioral risk reduction campaigns, and tailored preventive measures. Additionally, long-term data inform research priorities and foster innovation in treatments to address evolving disease patterns effectively.

Himachal Pradesh, a predominantly rural and hilly state in northern India, faces distinct public health challenges concerning chronic kidney disease (CKD). Geographic isolation, limited access to specialized healthcare facilities, and socioeconomic disparities significantly contribute to delayed diagnosis and treatment of CKD in the region [7]. Additionally, the state's evolving demographic profile, along with lifestyle changes and an increasing burden of non-communicable diseases, further intensifies the risk and prevalence of CKD in its population [8].

Nephrology services in Himachal Pradesh were first established at the Indira Gandhi Medical College (IGMC), Shimla, which served as the state's only tertiary care hospital providing nephrology care until recent years. The first hemodialysis (HD) procedure in the state was performed in 1977 [9], a landmark achievement in renal healthcare. Subsequently, a dedicated Department of Nephrology was established at the IGMC in 2002, expanding its capacity to comprehensively address kidney-related diseases [9]. This department provides care to both adult and pediatric inpatients requiring nephrology services and offers outpatient treatment for patients with non-dialysis CKD, acute kidney injury (AKI), and critical kidney-related conditions. These advancements underscore IGMC's critical role in addressing the growing burden of kidney diseases in the state.

Despite these developments, CKD research in India has predominantly focused on urban areas, leaving rural regions such as Himachal Pradesh underrepresented. This gap underscores the necessity for region-specific studies that incorporate local sociodemographic variables and healthcare access challenges to inform targeted interventions and equitable healthcare policies [13]. Given the increasing incidence of CKD in Himachal Pradesh, there is a pressing need to examine its prevalence, associated risk factors, and demographic groups that are most at risk. Investigating CKD epidemiology in rural and underserved populations can provide critical insights into disease burden and inform targeted interventions [11]. The present study aimed to fill this gap by identifying key risk factors, analyzing trends across age and gender, and generating data tailored to the specific healthcare challenges of the region. In doing so, it seeks to enhance understanding of CKD in rural and remote populations, contributing to improved prevention and management strategies at both the state and national levels.

The diagnosis of Chronic Kidney Disease (CKD) in the study adhered to the KDIGO 2012 clinical guidelines, ensuring consistency and precision. CKD was identified based on sustained eGFR <60 mL/min/1.73 $m^2$ or kidney damage markers (e.g., albuminuria ≥30 mg/g, structural abnormalities) for over three months. Laboratory assessments included serum creatinine (eGFR via CKD-EPI), albuminuria testing, and blood pressure monitoring. This rigorous methodology ensured reliable case identifica-

tion and facilitated accurate assessment of CKD prevalence and progression.

## Materials and Methods

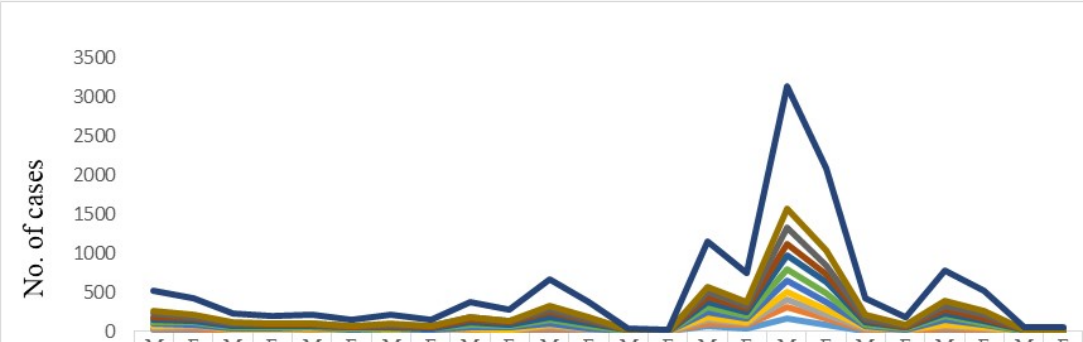
The present study utilized a retrospective observational design to analyze age, gender and temporal trends in Chronic Kidney Disease (CKD) among rural and urban populations of Shimla, Himachal Pradesh, India. Data on CKD cases were obtained from the Department of Nephrology, Indira Gandhi Medical College, Shimla, as part of the Hospital-Based Nephrology Registry, covering the period from 2014 to 2023. The study included confirmed CKD diagnoses among rural residents of Shimla district, excluding urban nonresidents of Himachal Pradesh. Demographic variables recorded included age (categorized as below 17 years and 68 years and above), place of residence, gender, and stage at diagnosis (classified based on kidney function from 90% to less than 15%, corresponding to stages I to V).

## Result and Discussion

This study addresses the following research questions:

### Research $_{\text{Question 1}}$: District-Wise CKD Distribution in Himachal Pradesh

Table 1 shows that a significant variations in CKD prevalence across the districts of Himachal Pradesh from 2014 to 2023. Shimla district consistently reported the highest number of cases, establishing itself as a critical region for CKD burden. Other districts with moderately high cases include Mandi (14.5%), Solan (10%), and Kullu (8.6%), whereas Lahaul & Spiti reported the lowest prevalence (0.6%), likely due to its sparse population and geographic isolation. A clear gender disparity was also evident, with males constituting 60.2% of the cases compared to 39.8% for females, highlighting the need for gender-specific strategies to address CKD burden.




| | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bilaspur | | Chamba | | Hamirpur | | Kinnaur | | Kangra | | Kullu | | Lahaul & spiti | | Mandi | | Shimla | | Sirmaur | | Solan | | Una | |
| Total | 261 | 210 | 119 | 103 | 109 | 78 | 108 | 78 | 192 | 141 | 337 | 189 | 24 | 12 | 577 | 371 | 1570 | 1039 | 215 | 96 | 390 | 259 | 29 | 28 |
| 2023 | 23 | 19 | 11 | 6 | 10 | 6 | 18 | 10 | 6 | 7 | 59 | 30 | 4 | 1 | 68 | 43 | 248 | 193 | 45 | 30 | 56 | 48 | 3 | 4 |
| 2022 | 48 | 30 | 11 | 10 | 11 | 8 | 20 | 6 | 28 | 13 | 26 | 28 | 2 | 2 | 69 | 32 | 201 | 113 | 23 | 8 | 46 | 40 | 4 | 5 |
| 2021 | 31 | 23 | 20 | 16 | 11 | 14 | 11 | 16 | 36 | 28 | 60 | 28 | 1 | 0 | 64 | 47 | 148 | 92 | 22 | 8 | 58 | 27 | 2 | 3 |
| 2020 | 35 | 13 | 18 | 12 | 16 | 12 | 12 | 13 | 32 | 25 | 37 | 31 | 8 | 0 | 61 | 40 | 169 | 143 | 32 | 10 | 31 | 37 | 11 | 6 |
| 2019 | 25 | 33 | 20 | 14 | 6 | 7 | 13 | 5 | 31 | 17 | 43 | 27 | 1 | 2 | 69 | 48 | 145 | 115 | 19 | 10 | 45 | 20 | 3 | 1 |
| 2018 | 28 | 10 | 11 | 20 | 14 | 9 | 12 | 6 | 14 | 20 | 24 | 11 | 3 | 0 | 63 | 34 | 145 | 99 | 24 | 6 | 60 | 36 | 2 | 5 |
| 2017 | 10 | 16 | 10 | 0 | 6 | 3 | 9 | 7 | 12 | 5 | 23 | 6 | 2 | 1 | 36 | 24 | 98 | 59 | 14 | 6 | 27 | 14 | 0 | 0 |
| 2016 | 17 | 25 | 5 | 5 | 5 | 3 | 2 | 6 | 10 | 6 | 22 | 7 | 1 | 2 | 35 | 22 | 102 | 57 | 13 | 5 | 23 | 12 | 2 | 4 |
| 2015 | 19 | 13 | 2 | 6 | 3 | 3 | 3 | 5 | 7 | 4 | 24 | 9 | 1 | 4 | 47 | 35 | 137 | 77 | 10 | 6 | 17 | 9 | 0 | 0 |
| 2014 | 25 | 28 | 11 | 14 | 27 | 13 | 8 | 4 | 16 | 16 | 19 | 12 | 1 | 0 | 65 | 46 | 177 | 91 | 13 | 7 | 27 | 16 | 2 | 0 |

## Research $_{\text{Question 2}}$: Gender-Wise CKD Distribution across Blocks in Shimla District

Table 2 demonstrates a significant gender disparity in the prevalence of Chronic Kidney Disease (CKD) in Shimla district. Among 2,609 cases, males constituted 60.2% (1,570 cases), significantly outnumbering females, who accounted for 39.8% (1,039 cases).

Table 3 further analyzes gender distribution across Shimla's blocks, revealing Mashobra with the highest cases (20.4%), followed by Theog (12.3%), and Kupvi with the lowest (2.4%). The Chi-square test result ($\chi^2 = 26.436$, $p < .01$) confirmed a significant difference in CKD distribution by gender across blocks, indicating a non-uniform gender impact of CKD across the district.

**Table 2:** Gender -Wise Distribution of Chronic Kidney Disease in Shimla District

| S. No | Gender | Frequency of CKD incidence | % |
|---|---|---|---|
| 1 | Male | 1570 | 60.2 |
| 2 | Female | 1039 | 39.8 |
| Total | | 2609 | 100 |

**Table 3:** Chi-square test showing the significance of differences between gender and blocks of Chronic Kidney Diseases

| Block | Male | Female | Total | $\chi^2$ |
|---|---|---|---|---|
| Chirgaon | 101 | 84 | 185 | 26.436** |
| Chaupal | 127 | 51 | 178 | |
| Rampur | 127 | 105 | 232 | |
| Rohru | 137 | 78 | 215 | |
| Theog | 209 | 113 | 322 | |
| Jubbal & Kotkhai | 143 | 85 | 228 | |
| Narkanda | 94 | 69 | 163 | |
| Mashobra | 314 | 217 | 531 | |
| Basantpur | 86 | 58 | 144 | |
| Kupvi | 42 | 21 | 63 | |
| Nankhari | 81 | 75 | 156 | |
| Shimla Urban | 109 | 83 | 192 | |

**$p < .01$

## Research $_{\text{Question 3}}$: Temporal Trends in CKD Prevalence across Genders (2014 to 2023)

Table 4 reveals significant temporal trends in CKD cases across genders from 2014 to 2023. The total cases peaked in 2023 (16.9%), with a subsequently high prevalence in 2022 (12%) and 2020 (12%). The lowest number of cases (6%) was reported in 2017. Gender distribution analysis shows males consistently outnumbering females, with the Chi-square test ($\chi^2 = 18.423$, $p < .05$) indicating significant gender differences over time. These findings highlight dynamic gender-related trends in CKD prevalence, emphasizing the need to address temporal variations in disease impact.

**Table 4:** Chi-square test showing the significance of differences between gender and years of CKD

| Year | Male | Female | Total | $\chi^2$ |
|---|---|---|---|---|
| 2014 | 177 | 91 | 268 | 18.423* |
| 2015 | 137 | 77 | 214 | |
| 2016 | 102 | 57 | 159 | |
| 2017 | 98 | 59 | 157 | |
| 2018 | 145 | 99 | 244 | |
| 2019 | 145 | 115 | 260 | |
| 2020 | 169 | 143 | 312 | |
| 2021 | 148 | 92 | 240 | |
| 2022 | 201 | 113 | 314 | |
| 2023 | 248 | 193 | 441 | |

*p < .05

## Research $_{\text{Question 4}}$: Interaction of Age and Gender in CKD Prevalence

Table 5 shows the interaction between age and gender is a critical determinant in understanding CKD prevalence, as demographic factors shape both risk exposure and disease progression. The study findings revealed distinct patterns. The highest prevalence was observed in the 57–67 years age group (637 cases, 29.1%), followed by the ≥68 years group (546 cases, 24.9%). The younger population (<17 years) exhibited the lowest prevalence (12 cases, 0.5%), suggesting that CKD predominantly affects middle-aged and older populations due to cumulative exposure to risk factors like hypertension, diabetes, and lifestyle changes. Whereas males consistently demonstrated higher CKD prevalence across all age groups. For instance, among individuals aged 57–67 years, 60.8% were males compared to 39.2% females. The disparity widened in the ≥68 years group, where males constituted 69% of cases, underscoring a potentially higher susceptibility or earlier onset among men. The chi-square test ($\chi^2 = 41.076$, $p < .000$) confirmed a highly significant association between age, gender, and CKD prevalence, emphasizing the need for demographic-specific analysis and intervention strategies.

**Table 5:** Chi-square test showing the significance of differences between age and gender of CKD

| Age | Gender of chronic kidney patients | | Total | $\chi^2$ |
|---|---|---|---|---|
| | Male | Female | | 41.076*** |
| <17 years | 8 | 4 | 12 | |
| 18-27 yrs | 101 | 56 | 157 | |
| 28-37 yrs | 173 | 101 | 274 | |
| 38-47 yrs | 214 | 204 | 418 | |

| | | | |
|---|---|---|---|
| 48-57 yrs | 310 | 255 | 565 |
| 57-67 yrs | 387 | 250 | 637 |
| 68 and above | 377 | 169 | 546 |

***p < .000

The study highlights significant disparities in Chronic Kidney Disease (CKD) prevalence across gender and age groups, prompting an in-depth exploration of underlying causes. These differences are likely driven by a combination of biological, behavioral, and healthcare access factors. Biologically, hormonal differences play a critical role; premenopausal estrogen provides renal protection, slowing CKD progression, but this benefit diminishes post-menopause, increasing CKD prevalence in older women. Males, with lower baseline renal reserve and faster glomerular filtration rate (GFR) decline, are more prone to earlier CKD onset. Testosterone may exacerbate renal injury, contrasting estrogen's protective effects [12]. Age-related factors, including natural GFR decline, nephron loss, and increased prevalence of comorbidities such as diabetes and hypertension, further heighten CKD risk [13].

Behavioral factors also significantly contribute to disparities. Men's higher exposure to smoking, alcohol consumption, and occupational hazards increases their CKD risk [1]. Their delayed healthcare-seeking behaviors often lead to late-stage diagnoses [14]. Women, while adopting healthier lifestyles, may face inadequate nutrition in resource-limited settings. Women's greater compliance with preventive measures and follow-ups may contribute to lower CKD prevalence but do not negate challenges like underdiagnosis due to socio-economic constraints. Age-and gender-specific sedentary lifestyles and unhealthy diets further shape CKD patterns.

Healthcare access disparities exacerbate these differences. Women often prioritize family healthcare needs over their own, delaying diagnosis and treatment. Limited awareness of CKD symptoms and socio-cultural barriers restrict women's access to specialized care, leading to underdiagnosis [15]. Conversely, healthcare systems' focus on men's comorbidities, like cardiovascular disease, may improve CKD detection rates in men. Older adults, facing mobility issues, financial constraints, and caregiver shortages, often struggle to access care. Although age-specific programs improve detection in older populations, younger individuals remain underserved, emphasizing the need for balanced, inclusive healthcare policies.

## Research $_{\text{Question 5}}$: Age Groups and Temporal Patterns in CKD Diagnosis

Table 6 shows the relationship between age groups and years of CKD diagnosis. CKD cases peaked in 2023 (441 cases, 26.5% from the 57-67 years group), followed by 2022 (314 cases) and 2020 (312 cases). The lowest number of cases was observed in 2017 (157). The 57-67 years group consistently recorded the highest cases across most years. The Chi-square test ($\chi^2 = 124.625$, $p < .000$) indicated a significant association between age groups and years of diagnosis, emphasizing that CKD prevalence is influenced by both age and temporal factors. These findings highlight the need for age-specific interventions and monitoring of temporal trends.

**Table 6:** Chi-square test showing the significance of differences between age and years of CKD

| Year | Below 17 yrs | 18-27 yrs | 28-37 yrs | 38-47 yrs | 48-57 yrs | 57-67 yrs | 68 and above | $\chi^2$ |
|---|---|---|---|---|---|---|---|---|
| 2014 | 0 | 16 | 36 | 47 | 69 | 69 | 31 | 124.625*** |
| 2015 | 1 | 15 | 20 | 21 | 41 | 53 | 63 | |
| 2016 | 0 | 9 | 19 | 23 | 32 | 34 | 42 | |
| 2017 | 0 | 8 | 26 | 29 | 18 | 34 | 42 | |
| 2018 | 1 | 20 | 28 | 37 | 60 | 54 | 44 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2019 | 3 | 15 | 20 | 48 | 63 | 69 | 42 |
| 2020 | 4 | 20 | 50 | 52 | 70 | 62 | 54 |
| 2021 | 2 | 17 | 16 | 45 | 52 | 66 | 42 |
| 2022 | 0 | 25 | 33 | 39 | 61 | 79 | 77 |
| 2023 | 1 | 12 | 26 | 77 | 99 | 117 | 109 |
| Total | 12 | 157 | 274 | 418 | 565 | 637 | 546 |

***p < .000

## Conclusion

The present study highlights significant spatial, temporal, gender, and age-related variations in the incidence of Chronic Kidney Disease (CKD) across Himachal Pradesh from 2014 to 2023. The Shimla district consistently emerged as the region with the highest CKD prevalence (39.9%), followed by Mandi (14.5%), Solan (10%), and Kullu (8.6%), while Lahaul and Spiti reported the lowest prevalence (0.6%). CKD prevalence was notably higher among males (60.2%) than among females (39.8%), with pronounced gender disparities observed across various blocks, particularly in Mashobra, which recorded the highest cases for both genders.

Over the years, CKD cases have shown a discernible upward trend, peaking in 2023 (16.9% of total cases) and reaching their lowest prevalence in 2017 (6%), potentially reflecting variations in disease detection or reporting. Age-specific patterns indicated that the 57–67 and 68+ age groups accounted for the majority of CKD cases, with minimal representation among those under 17 years. Furthermore, the 57–67 years age group consistently demonstrated the highest prevalence across most years, notably in 2023, suggesting evolving risk factors or improved diagnostic practices.

These findings underscore the urgent need for targeted, evidence-based interventions that address spatial, gender, and age-related disparities in CKD prevalence. Continuous monitoring, enhanced screening efforts, and tailored prevention strategies, particularly in high-prevalence districts and vulnerable populations, are critical for mitigating the growing CKD burden and improving public health outcomes across Himachal Pradesh.

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## Conflicts of Interest

There is no conflict of interest

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