ORIGINAL ARTICLE

INTEGRATED HEALTH COMMUNITY'S COLLABORATIVE PREVENTION AND TREATMENT MODEL FOR CHRONIC KIDNEY DISEASE MANAGEMENT

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ABSTRACT

This study aimed to evaluate the association between implementation of an integrated health community model and changes in renal function indicators and case-mix composition among patients with chronic kidney disease (CKD). A single-centre retrospective study was conducted among 578 patients diagnosed with CKD at Jiangqiao Hospital, Jiading District, Shanghai, between January 2021 and June 2024. Renal function indicators, including serum creatinine (Cr), blood urea nitrogen (BUN), uric acid (UA), and estimated glomerular filtration rate (eGFR), were assessed, and annual distributions of CKD stages were examined. Interrupted time series analysis using segmented linear regression with Newey–West standard errors (lag = 1) was performed to evaluate immediate level changes and post-intervention slope changes following implementation of the integrated health community model in July 2021. Significant immediate changes were observed for Cr, BUN, and eGFR, with Cr increasing by 347.94 μmol/L ($p = 0.009$), BUN by 9.79 mmol/L ($p = 0.023$), and eGFR decreasing by 22.99 mL/min/1.73 m^2 ($p < 0.001$), while the immediate change in UA was not statistically significant (74.82 μmol/L, $p = 0.052$). A significant post-intervention slope change was observed for eGFR ($\beta = -3.30$, $p < 0.001$), whereas changes in Cr ($\beta = 18.49$, $p = 0.098$) and UA ($\beta = 12.89$, $p = 0.076$) were not statistically significant, and no significant slope change was observed for BUN ($\beta = 0.00$, $p = 0.997$). The CKD stage distribution also indicated an increased proportion of patients with advanced CKD, particularly Stage 4–5 disease, following implementation. Implementation of the integrated health community model was associated with changes in renal function indicators and a shift towards a greater proportion of patients with advanced CKD. This pattern may reflect improved case identification and referral through systematic screening and standardised community-based care pathways rather than solely reflecting disease progression. The integrated health community model may therefore provide a feasible approach for strengthening CKD detection and management in community settings, although further prospective controlled studies are required to determine its long-term effectiveness.

Keywords: *Integrated health community; Chronic kidney disease; Interrupted time series analysis; Case-mix; Disease management*

INTRODUCTION

Chronic diseases have become a major public health challenge in China, placing an increasing burden on the healthcare system. According to the National Health Commission and the Report on the Nutrition and Chronic Disease Status of Chinese Residents (2020), chronic diseases accounted for 88.5% of all deaths in China in 2019.[1] This burden is further amplified by population ageing, with individuals aged ≥60 years accounting for 18.70% of the national population and 23.38% of the population in Shanghai.[2] Among chronic conditions, chronic kidney disease (CKD) is of particular concern because of its high prevalence, often asymptomatic progression, and substantial healthcare and economic burden.[3,4] The estimated prevalence of CKD in China is approximately 10.8%, corresponding to more than 100 million adults, while disease awareness remains low and many patients are diagnosed only after progression to advanced stages.[5]

To address the increasing burden of chronic diseases, China has promoted the development of medical alliances to strengthen collaboration between tertiary hospitals and primary healthcare institutions through mechanisms such as telemedicine, resource sharing, and standardised referral pathways.[6] However, several challenges continue to limit the effectiveness of chronic disease management at the community level. These include inadequate health awareness and self-management skills among residents, limited opportunities for primary healthcare providers to update their professional knowledge, and insufficiently defined coordination mechanisms between tertiary hospitals and community health centres.[6,7] Such limitations may contribute to fragmented care, delayed disease detection, and inefficient utilisation of healthcare resources.

In response to these challenges, Jiading District, Shanghai, introduced the "integrated health community" model in July 2021 within the

framework of a close-knit medical alliance. The model was designed to integrate disease prevention, diagnosis, treatment, and long-term management across different levels of healthcare, with particular emphasis on systematic screening, standardised referral, multidisciplinary collaboration, and continuous follow-up.[8] Jiangqiao Hospital functions as a core institution within this integrated health community and collaborates with primary healthcare centres to implement coordinated approaches to chronic disease prevention and management.

Although previous studies have primarily evaluated CKD management outcomes within individual healthcare institutions,[9] evidence on the population-level effects of integrated health community models remains limited. In particular, changes in renal function indicators following implementation of such models may reflect not only changes in disease management but also changes in the characteristics of patients identified and enrolled through enhanced screening and referral. Distinguishing between these possibilities is important when evaluating the effectiveness of integrated care models and interpreting changes in clinical indicators at the population level.

Therefore, this study aimed to examine temporal trends in renal function indicators, including serum creatinine (Cr), blood urea nitrogen (BUN), uric acid (UA), and estimated glomerular filtration rate (eGFR), among patients with CKD enrolled in the integrated health community between 2021 and 2024. Using interrupted time series analysis, we further assessed whether implementation of the integrated health community model in July 2021 was associated with immediate and subsequent changes in renal function indicators and patient case-mix composition. The findings provide preliminary real-world evidence on the population-level implications and operational impact of an integrated community-based approach to CKD management.

METHODOLOGY

Study design and participants

This single-centre retrospective study was conducted at Jiangqiao Hospital, Jiading District, Shanghai, using data from patients with chronic kidney disease (CKD) enrolled during the implementation of the integrated health community model. A total of 578 patients diagnosed with CKD during the study period were included. The study population comprised 357 males and 221 females, with a mean age of 67.88 ± 12.26 years. Patients were eligible for inclusion if they met the diagnostic criteria for CKD, were aged ≥18 years, were permanent residents of the community, and had the cognitive capacity to provide relevant medical history and cooperate with clinical assessment. Patients were excluded if they had severe cognitive impairment, a history of dementia or severe mental illness, or were unable to provide reliable medical history because of other conditions. Pregnant or breastfeeding women, patients with acute kidney injury, acute diarrhoea, severe infectious diseases, those receiving peritoneal dialysis or haemodialysis, and patients with conditions that substantially reduced life expectancy, such as malignancy, were also excluded.

Data collection

Clinical and laboratory data were retrospectively extracted from the hospital records of eligible patients. The primary renal function indicators included serum creatinine (Cr), blood urea nitrogen (BUN), uric acid (UA), and estimated glomerular filtration rate (eGFR). Additional routine clinical and biochemical indicators included systolic blood pressure (SBP), diastolic blood pressure (DBP), glycated haemoglobin (HbA1c), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG).

The observation period extended from January 2021 to June 2024, covering periods before and after implementation of the integrated health community model in July 2021. Individual patient-level observations were aggregated by calendar month to obtain monthly mean values for each renal function indicator. The monthly aggregated data were subsequently used for the interrupted time series (ITS) analysis.

Statistical analysis

Statistical analyses were performed using Stata/MP version 17.0 (StataCorp, College Station, TX, USA). Continuous variables were summarised as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Time-series plots were generated to describe temporal trends in renal function indicators during the study period. An interrupted time series (ITS) analysis using segmented linear regression was performed to assess whether implementation of the integrated health community model in July 2021 was associated with changes in renal function indicators.[10] A continuous time variable was generated and coded sequentially for each month of the observation period. The intervention variable indicated the implementation of the integrated health community model, with July 2021 designated as the intervention point. An interaction term between time and the intervention indicator was included to estimate the change in the post-intervention trend compared with the pre-intervention trend. The segmented regression model was specified as:

$$Y_t = \beta_0 + \beta_1 \text{Time}_t + \beta_2 \text{Intervention}_t + \beta_3 \text{Post-intervention Time}_t + \varepsilon_t$$

where Y_t represents the monthly mean value of the outcome at time *t*; β_0 represents the baseline level of the outcome at the beginning of the observation period; β_1 represents the pre-intervention monthly trend; β_2 represents the immediate change in the outcome level following implementation of the integrated health community model in July 2021; and β_3 represents the change in slope after implementation, corresponding to the difference between the post-intervention and pre-intervention trends. The residual error term is represented by ε_t. To account for potential autocorrelation in the time-series observations, Newey–West standard errors with a lag of 1 were used. Statistical significance was assessed using two-sided tests, with a p-value <0.05 considered statistically significant.

RESULTS

Characteristics of the study population

A total of 578 patients with CKD were included in the study, comprising 357 males (61.76%) and 221 females (38.23%), with a mean age of 67.88 ± 12.26 years. The annual characteristics and clinical indicators of the study population are presented in Table 1. The mean systolic blood pressure (SBP) ranged from 140.00 to 143.95 mmHg, while the mean diastolic blood pressure (DBP) ranged from 75.04 to 78.39 mmHg during the study period. The highest mean SBP (143.95 ± 21.86 mmHg) and DBP (78.39 ± 12.67 mmHg) were observed in 2022. The mean HbA1c decreased from 6.41 ± 1.34% in 2021 to 5.84 ± 0.87% in 2022 and remained relatively stable thereafter. Similarly, mean TC, LDL-C, and TG generally decreased over the study period, with the lowest values observed in 2024.

Renal function indicators showed greater variation across the study period. Mean serum creatinine (Cr) increased from 301.46 ± 218.95 μmol/L in 2021 to 603.38 ± 340.45 μmol/L in 2022, followed by a gradual decline to 514.15 ± 254.72 μmol/L in 2024. Mean BUN increased from 19.64 ± 11.12 mmol/L in 2021 to 25.53 ± 11.74 mmol/L in 2022 before declining to 21.02 ± 9.28 mmol/L in 2024. Mean UA increased from 457.40 ± 111.53 μmol/L in 2021 to 474.79 ± 140.09 μmol/L in 2022 and subsequently declined to 424.19 ± 127.33 μmol/L in 2024. In contrast, mean eGFR decreased progressively from 34.39 ± 26.04 mL/min/1.73 m^2 in 2021 to 16.87 ± 16.62 mL/min/1.73 m^2 in 2024.

Temporal trends in renal function indicators

The monthly temporal trends in renal function indicators are shown in Figure 1. Serum Cr increased after implementation of the integrated health community model and reached its highest levels during mid-to-late 2022, followed by a gradual decline. BUN showed an increase around the intervention period and subsequently demonstrated a downward trend. UA exhibited an overall fluctuating pattern, with a peak during early 2023 followed by a gradual decline. eGFR showed considerable temporal variation, with an increase during part of the post-intervention period before declining subsequently. Overall, the monthly trends demonstrated substantial fluctuations in renal function indicators during the observation period.

Interrupted time series analysis

The results of the interrupted time series analysis are presented in Table 2. Before implementation of the integrated health community model in July 2021, the monthly trend in Cr was negative but not statistically significant (β = −17.51, p = 0.114). BUN also showed no significant pre-intervention trend (β = −0.14, p = 0.854). In contrast, UA demonstrated a significant declining pre-intervention trend (β = −15.18, p = 0.036), while eGFR showed a significant increasing pre-intervention trend (β = 2.96, p < 0.001). A significant immediate level increase following implementation was observed for Cr (β = 347.94 μmol/L, p = 0.009) and BUN (β = 9.79 mmol/L, p = 0.023), whereas eGFR showed a significant immediate decrease of 22.99 mL/min/1.73 m^2 (p < 0.001). The immediate change in UA was not statistically significant (β = 74.82 μmol/L, p = 0.052). Regarding post-intervention trends, eGFR demonstrated a significant decline in slope (β = −3.30 mL/min/1.73 m^2 per month, p < 0.001). Changes in the slopes of Cr (β = 18.49 μmol/L per month, p = 0.098) and UA (β = 12.89 μmol/L per month, p = 0.076) were not statistically significant, while no change in the BUN slope was observed (β = 0.00 mmol/L per month, p = 0.997).

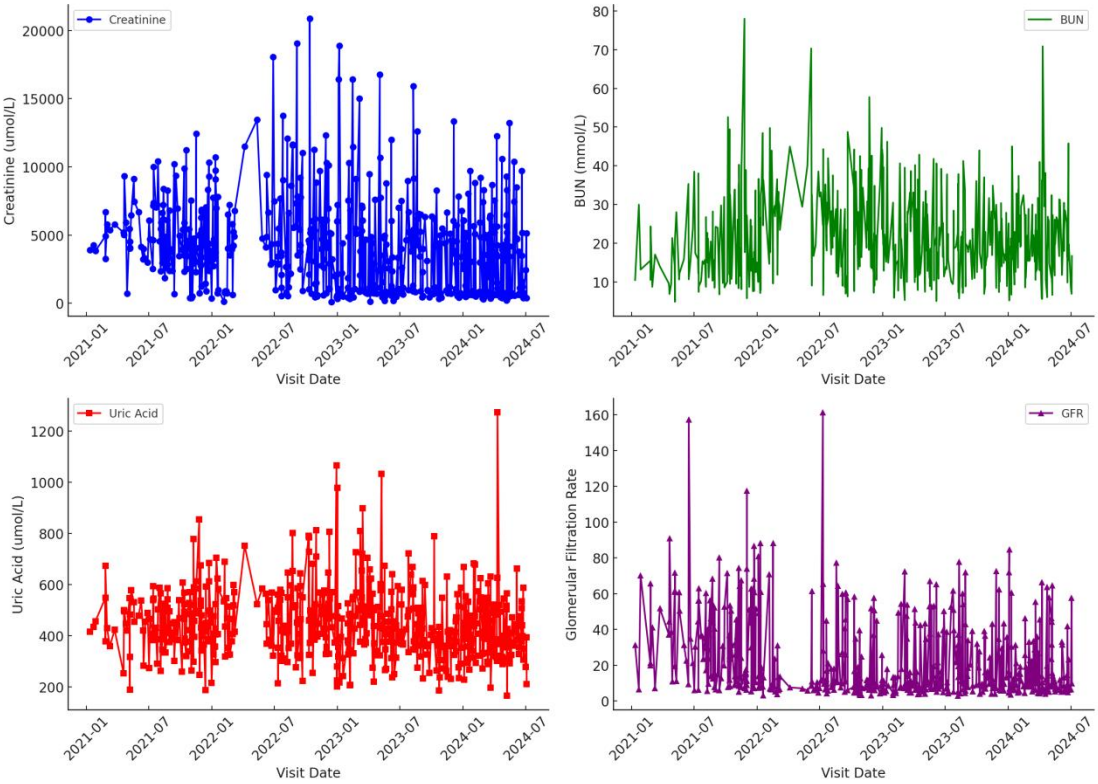

Figure 1: Time Series of Kidney Function Indicators

Table 1: Annual distribution of demographic characteristics and clinical indicators among patients with chronic kidney disease

Variable(mean±SD)	Total	2021	2022	2023	2024
Age	67.88±12.26	68.63±12.64	66.99±12.81	67.29±13.16	68.89±9.83
Gender(count/percent %)					
Male	357(61.76)	73(58.87)	92(67.15)	120(65.57)	72(53.73)
Female	221(38.23)	51(41.13)	45(32.84)	63(34.42)	62(46.27)
SBP(mmHg)	141.83±23.91	140.34±23.48	143.95±21.86	140±24.57	143.85±25.16
DBP(mmHg)	76.08±12.84	75.13±13.59	78.39±12.67	75.83±13.19	75.04±11.67
HbA1c(%)	6.1±1.15	6.41±1.34	5.84±0.87	6.08±1.19	6.06±1.08
TC(mmol/L)	3.84±1.13	4.18±1.19	3.86±1.08	3.78±1.11	3.53±1.07
LDL-C(mmol/L)	2.2±0.96	2.44±1.07	2.27±0.91	2.2±0.94	1.86±0.84
TG(mmol/L)	1.76±1.21	2.01±1.16	1.58±0.88	1.9±1.57	1.52±0.86
Cr(μmol/L)	497.24±311.06	301.46±218.95	603.38±340.45	568.67±307.37	514.15±254.72
BUN(mmol/L)	21.84±10.66	19.64±11.12	25.53±11.74	21.15±9.8	21.02±9.28
UA(μmol/L)	448.22±132.47	457.4±111.53	474.79±140.09	439.57±140.07	424.19±127.33
eGFR(ml/min/1.73m²)	22.39±22.2	34.39±26.04	20.48±23.79	19.47±18.37	16.87±16.62

Table 2: Interrupted Time Series Analysis of Renal Function Indicators Before and After Policy Implementation

Variable	Pre-intervention trend (time)	Immediate level change (intervention)	Post-intervention slope change (time after)
Cr(μmol/L)	-17.51 (p=0.114)	347.94 (p=0.009)	18.49 (p=0.098)
BUN(mmol/L)	-0.14 (p=0.854)	9.79 (p=0.023)	0.00 (p=0.997)
UA (μmol/L)	-15.18 (p=0.036)	74.82 (p=0.052)	12.89 (p=0.076)
eGFR (mL/min/1.73m²)	2.96 (p<0.001)	-22.99 (p<0.001)	-3.30 (p<0.001)

DISCUSSION

The integrated health community model is based on the concept of a close-knit medical alliance and aims to shift healthcare delivery towards a more health-centred approach through integration of prevention, treatment, and health management. Since the implementation of China's healthcare reforms, different regions have explored integrated medical alliance models to strengthen coordination among tertiary hospitals, secondary hospitals, and community healthcare institutions. These approaches are intended to promote more efficient allocation of healthcare resources and support the implementation of a hierarchical healthcare delivery system.[11,12] However, high-quality medical resources in China remain concentrated predominantly in large tertiary hospitals, while primary healthcare institutions continue to face limitations in human resources, expertise, and service capacity.[13] This imbalance has contributed to high patient volumes in tertiary hospitals and relatively lower utilisation of primary healthcare services.[14] In 2020, hospitals, which represented less than 3% of medical institutions nationally, accounted for approximately 38% of patient visits, whereas primary healthcare institutions, representing nearly 97% of medical institutions, accounted for approximately 43% of visits.[15] These challenges highlight the need for integrated models that can strengthen coordination between different levels of healthcare and improve the distribution and continuity of chronic disease services.

Using CKD as an example, this study examined temporal changes in renal function indicators following implementation of the integrated health community model in Jiading District, Shanghai. The ITS analysis demonstrated significant immediate increases in serum Cr and BUN and a significant immediate decrease in eGFR following implementation in July 2021. Although UA also increased immediately after implementation, this change did not reach conventional statistical significance (p = 0.052). In addition, eGFR demonstrated a significant change in its post-intervention slope, whereas the post-intervention slope changes for Cr, BUN, and UA were not statistically significant. These findings indicate that implementation of the integrated health community model was temporally associated with a substantial change in the renal function profile of the population managed within the programme.

The apparent worsening of renal function indicators immediately after implementation requires careful interpretation. Rather than demonstrating that the integrated health community model caused deterioration in renal function, the findings may reflect a change in the composition of patients identified, referred, and enrolled following implementation of systematic screening and coordinated referral pathways. Patients with previously undiagnosed or more advanced CKD may have been more likely to enter the healthcare system after implementation of the integrated model. Consequently, the post-intervention population may have had a different clinical profile from the population observed before implementation. This possibility is particularly relevant when evaluating population-level interventions in which changes in case ascertainment can alter the observed distribution of disease severity.

The immediate change observed around the intervention point provides some support for this interpretation, although it does not establish causality. A sudden change in population-level renal indicators is compatible with a change in case ascertainment or referral patterns, whereas progression of CKD among an established cohort would generally be expected to occur over a longer period. Nevertheless, other explanations, including changes in healthcare utilisation, treatment patterns, patient characteristics, or unmeasured secular factors, cannot be excluded. Previous studies of integrated chronic disease programmes have demonstrated the potential of integrated approaches to strengthen coordination and chronic disease management.[16] For example, the Leicester, Leicestershire, and Rutland Chronic Kidney Disease Integrated Care Delivery Programme (LUCID) integrated specialist

expertise into community-based care and incorporated early disease identification, medicines optimisation, risk stratification, and disease surveillance.[17]

The concurrent direction of the renal biomarkers also provides biological coherence to the observed population-level changes. Serum Cr, BUN, and UA are influenced by renal clearance, while eGFR provides an estimate of kidney filtration function. A population with a greater proportion of patients with advanced CKD would therefore be expected to demonstrate higher concentrations of renal metabolic markers together with lower eGFR. In the present study, the immediate increase in Cr and BUN accompanied by a decrease in eGFR is consistent with such a shift. However, this pattern alone cannot distinguish changes in case-mix from changes in individual patients' renal function. Longitudinal patient-level follow-up would be required to determine whether individuals experienced actual changes in kidney function after enrolment.

The findings have important implications for evaluating integrated healthcare models. First, changes in the clinical profile of enrolled patients should be considered when assessing population-level outcomes. Changes in screening, information provision, and healthcare delivery may alter the characteristics of patients identified and managed within a healthcare programme, potentially affecting population-level outcome measures.[18] Consequently, an apparent worsening of laboratory indicators after implementation does not necessarily indicate failure of the intervention. An intervention that improves screening and referral may initially increase the proportion of patients with more advanced disease because previously undetected cases are brought into care.

The experience of integrated CKD programmes in other settings provides further support for the potential value of coordinated care. The LUCID programme in the United Kingdom incorporated specialist expertise into community-based care and implemented early disease identification, medicines optimisation, and disease surveillance through multidisciplinary collaboration.[17] The programme has subsequently continued to expand, with the integrated service recognised for its population-based approach to improving CKD care and supporting appropriate management through local primary care services.[19] Similarly, a three-team co-management model involving specialist physicians, general practitioners, and health managers has been reported to support standardised screening, individualised intervention, and continuous follow-up of patients with CKD in China.[20] The Gateshead FACTS CKD Project also demonstrated the potential of digitally supported case finding and structured medication review to improve identification and management of CKD.[21] These findings suggest that strengthening links between primary and specialist care may improve the identification and management of patients with CKD, although differences in healthcare systems and study designs limit direct comparison with the present study.

CONCLUSION

Implementation of the integrated health community model was associated with substantial changes in the population-level renal function profile of patients with CKD, characterised by immediate increases in serum creatinine and BUN and a decrease in eGFR, together with an increase in the proportion of patients with advanced CKD (Stage 4–5), from 35.7% in 2021 to 86.6% in 2024. These findings may reflect enhanced case ascertainment and referral of patients with previously unrecognised or more advanced CKD following the implementation of systematic screening and standardised referral pathways. However, the present study cannot determine whether the observed changes resulted from altered case-mix composition, disease progression, or other time-varying factors. The integrated health community model may therefore provide a feasible approach to strengthening CKD detection, referral, and continuity of care at the community level. Prospective multicentre longitudinal studies with appropriate comparison groups and adjustment for time-varying confounders are warranted to determine its effects on renal function trajectories and long-term patient outcomes.

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Conflict of Interest
No potential conflict of interest relevant to this article was reported

Authors' contribution
Wan Zhiqiang (WZQ), Thamilvaani Manaharan (TM), Cao Jiamin (CJM) designed and conceived the research. Wang Junyan (WJY) analysed and interpreted the data. WZQ and CJM drafted the article. Jin Qilin (JQL) and TM contributed to the overall supervision of the project. All the authors have reviewed this manuscript.

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