

# Distribution of pathological types and epidemiological characteristics based on kidney biopsy in Northwest China

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**Background:** The spectrum of biopsy-confirmed kidney disease varies with regions and periods. We describe the distribution of pathological types and epidemiological characteristics of kidney diseases in Northwest China due to regional differences in geographical environment, social economy, and dietary habits.

**Methods:** Kidney biopsy cases from 2005 to 2020 in Xijing Hospital were retrospectively analyzed. Pathological characteristics of patients in different periods were analyzed using the t test or chi-square test. Joinpoint regression was used to analyze trends in pathological types and disease spectrum.

**Results:** A total of 10,528 eligible patients were included. Primary glomerular disease (PGD) accounted for the majority of the cases and exhibited an obvious downward trend, whereas secondary glomerular disease (SGD) showed an obvious upward trend. Among PGD, immunoglobulin A nephropathy (IgAN) remained the most common pathological type, and the detection rate of membranous nephropathy (MN) was significantly increased. Among SGD, Henoch-Schönlein purpura nephritis (HSPN) was the most common pathological type and may present a significant characteristic of Northwest China. Diabetic nephropathy (DN) exhibited the most obvious upward trend in the whole process, whereas the fastest growth since 2012 was in hypertensive nephropathy.

**Conclusion:** The proportion of SGD increased whereas PGD declined. IgAN remained the most common PGD, and HSPN was the most common SGD. MN and DN showed the most obvious upward trend among PGD and SGD, respectively. Changes in the spectrum of kidney disease, especially the constituent ratio of SGD, pose a great challenge to public health.

**Keywords:** China, Biopsy, Epidemiology, Kidney disease, Pathology

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## Introduction

In 2020, the Global Burden of Disease organization indicated that the global burden of kidney disease was increasing year by year [1]. At present, there are over 100 million people with chronic kidney disease (CKD) in China, and the percentage of hospitalized patients with the disease has increased from 3.58% (2010) to 4.95% (2017) [2]. To delay the progression to end-stage kidney disease (ESKD), the underlying etiology and pathology need to be clarified at the initial diagnosis.

The epidemiological study of nephropathy is helpful for early diagnosis and treatment in addition to understanding the epidemic trend of the disease. However, the differences in geographical environment, social economy, and dietary habits in different regions or countries contribute to the variation in the spectrum of kidney disease [3]. Intriguingly, the kidney disease spectrum varied in the same region even during a short period [4]. For example, in countries in East Asia, the detection rate of immunoglobulin A nephropathy (IgAN) and mesangial proliferative glomerulonephritis (MsPGN) can exceed 50% and the prevalence of IgAN and MsPGN has decreased in recent decades [5–7]. In China, the spectrum of kidney disease has changed due to the increasing incidence of hypertension, obesity, diabetes, and the increasing average age of the population [8]. In the United States, the frequency of diabetic kidney disease has increased dramatically over the past 30 years, whereas focal segmental glomerulosclerosis (FSGS) has declined over the past decade [9]. Therefore, it is of great significance to understand the updated epidemiological characteristics of kidney disease in a certain area and a fixed period to guide policy decisions on prevention in public health and therapeutic strategies in clinical practice [2].

Northwest China, located in the interior of China, is characterized by a vast area, drought and water shortages, extensive deserts, sandstorms, and a fragile ecology [10]. Due to the change in people's economic conditions and lifestyles in recent years, we hypothesize that the population of Northwest China has a distinct spectrum of kidney diseases. However, contemporary large-scale epidemiological studies of kidney disease from Northwest China are lacking. Thus, we retrospectively analyzed a kidney biopsy cohort from the largest clinical center in Northwest China to explore the specific epidemiological characteristics of

the kidney disease spectrum.

## Methods

### Study objective

Pathological and clinical data of 10,879 inpatients who underwent a kidney biopsy in Xijing Hospital (Air Force Military Medical University, Xi'an, China) from December 2005 to December 2020 were screened. Inclusion criteria were as follows: (1) patients who underwent a percutaneous kidney biopsy with ultrasound localization; (2) light microscopy, immunofluorescence, and electron microscopy were performed; (3) undiagnosed renal amyloidosis that required an abdominal fat pad biopsy and Congo red staining; and (4) in patients who had multiple biopsies, only the first result was included. Exclusion criteria were: (1) absence of original pathology report; (2) kidney transplant donors and patients; and (3) unsatisfactory biopsy specimens (the number of glomeruli in biopsy specimens was less than eight).

### Data collection

Clinical and pathological data were collected by two researchers (Qin and Zhao). Pathological diagnosis was determined by consultation between the pathologist and clinician. Demographic data, diagnostic information, and laboratory data at the time of kidney biopsy were retrieved from electronic medical record information systems. This retrospective study was approved by the ethics committee of Xijing Hospital (No. KY20213027-1) and performed in accordance with the Declaration of Helsinki. Because of the retrospective design of the study, the need to obtain informed consent from eligible patients was waived by the ethics committee. We strictly protected the privacy of subject information during and after data collection.

### Classification of clinicopathological diagnosis

According to the 1982 World Health Organization (WHO) histological classification of glomerular diseases [11] and the 1995 revision for glomerular diseases, renal histopathological diagnosis was classified as follows: (1) primary glomerular disease (PGD): IgAN, FSGS, MsPGN, mem-

branoproliferative glomerulonephritis (MPGN), membranous nephropathy (MN), minimal change disease (MCD), crescentic glomerulonephritis (CreGN), endocapillary proliferative glomerulonephritis (EnPGN), IgM nephropathy (IgMN), sclerosing glomerulonephritis (SCGN), and unclassified; (2) secondary glomerular disease (SGD): Henoch-Schönlein purpura nephritis (HSPN), lupus nephritis (LN), diabetic nephropathy (DN), hypertensive nephropathy (HTN), hepatitis B associated nephropathy (HBVN), systemic vasculitis-associated renal damage (SVARD), proliferative glomerulonephritis with monoclonal immunoglobulin deposition (PGNMID), obesity-associated glomerulopathy (OAG), etc.; (3) hereditary nephropathy (HN): thin basement membrane nephropathy, Alport syndrome, Fabry disease etc.; (4) tubulointerstitial nephritis (TIN); and (5) other nephropathies were defined as unqualified morphological changes for WHO classification. Patients with two or more types of pathological diagnoses were re-analyzed by clinical nephrologists and pathologists in our center to determine the most important pathologic lesions.

The clinical diagnoses for kidney biopsy were categorized into six groups: (1) asymptomatic urinary abnormalities (AUA); (2) chronic nephritic syndrome (CNS); (3) nephrotic syndrome (NS); (4) acute kidney injury (AKI); (5) rapidly progressive glomerulonephritis (RPGN); and (6) others. These biopsy indicators have remained roughly the same over the past two decades. However, with the progression of technology, the relative contraindications of biopsy age and blood pressure requirements for elderly patients have been relaxed.

### Statistical analysis

All patients enrolled were grouped according to a 5-year interval (period 1: 2005–2010, period 2: 2011–2015, and period 3: 2016–2020) and divided into five age groups for stratified analysis: ≤14, 15–30, 31–45, 46–60, and >60 years of age. The proportion of each pathological type in the total number was converted into a constituent ratio: (number of observed units of a certain component/total number of observed units of each component of the same object) × 100%. The Joinpoint Regression Program (JPR) statistical software version 4.9.0.0 (Statistical Research and Applications Branch, National Cancer Institute, USA) established

the time component ratio sequence data using multiple joinpoint models (<https://surveillance.cancer.gov/help/joinpoint>) and was used for the regression analysis of the trend of the constituent ratio. The annual percentage change (APC) and average APC (AAPC) within the complete time interval of each rate were estimated using the optimal joinpoint model. IBM SPSS version 24.0 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Continuous variables were expressed as means ± standard deviation, and intergroup comparisons were performed by the chi-square test. A statistically significant difference was set at  $p < 0.05$ .

### Results

A total of 10,528 patients with clinicopathological data were included (Table 1). In summary, the proportions of various pathological subgroups were as follows: PGD (71.1%), SGD (26.1%), TIN (2.1%), HN (0.6%), and others (0.1%). The leading cause of PGD was IgAN (30.1%), followed by MN (20.1%), MsPGN (8.0%), FSGS (4.6%), MCD (3.7%), IgMN (1.6%), and SCGN (1.1%). The leading cause of SGD was HSPN (7.8%), followed by LN (6.4%), DN (3.8%), HTN (2.3%), HBVN (1.6%), renal amyloidosis (1.5%), and SVARD (1.2%) (Supplementary Table 1, available online).

**Table 1. Baseline characteristics of kidney biopsy patients (n = 10,528)**

Characteristic	Value
Male sex	6,004 (57.0)
Age (yr)	38.73 ± 16.53
No. of glomeruli	22.19 ± 10.34
Asymptomatic urinary abnormalities	1,486 (14.1)
Chronic nephritic syndrome	5,429 (51.6)
Nephrotic syndrome	3,157 (30.0)
Acute kidney injury	405 (3.8)
Rapidly progressive glomerulonephritis	29 (0.3)
Isolated microscopic hematuria	879 (8.3)
Renal insufficiency <sup>a</sup>	1,850 (17.6)
Hypertension	3,147 (29.9)
Hyperlipidemia	3,963 (37.6)
Renal anemia	1,066 (10.1)

All data are presented as values at the time of kidney biopsy. Data are expressed as number (%) and mean ± standard deviation.

<sup>a</sup>Estimated glomerular filtration rate, <60 mL/min/1.73 m<sup>2</sup>.

## Demographic characteristics

The geographical distribution of enrolled cases was mainly from Northwest China, including Shaanxi (60.2%), Gansu (18.5%), Shanxi (9.7%), Ningxia (4.4%), Qinghai (1.7%), and Xinjiang (0.3%), with a male/female ratio of 1.37:1. Their ages range from 6 to 88 years, and the average age was  $38.73 \pm 16.53$  years. Regarding common pathologic types, the youngest participant had EnPGN ( $23.69 \pm 18.49$ ), whereas the oldest had renal amyloidosis ( $58.88 \pm 9.01$ ) (Table 2). During different periods, there was a significant

increase in the average age (period 1:  $34.34 \pm 16.19$ , period 2:  $37.75 \pm 16.52$ , period 3:  $41.93 \pm 16.07$ ;  $p < 0.001$ ) (Table 3). Patients aged 46–60 years increased from 17.4% to 28.0%, and those aged >60 years increased from 7.9% to 14.7% ( $p < 0.001$ ). IgAN and HSPN had age distribution peaks in the 15–30-year age group (41.1% and 39.2%), whereas MN had age distribution peaks in the 45–60-year age group (34.3%) (Fig. 1A). The largest proportion of male appears in the HTN group, whereas the largest proportion of female appears in the LN group (Fig. 1B).

**Table 2.** Comparative analysis of common pathological types and age stratification

Pathological diagnosis	Age (yr)	Total (n = 10,528)	Age group (yr)				
			≤14	15–30	31–45	45–60	>60
IgAN	$34.53 \pm 13.63$	3,165 (30.1)	129 (4.1)	1,301 (41.1)	1,078 (34.1)	504 (15.9)	153 (4.8)
MN	$46.16 \pm 16.11$	2,111 (20.1)	17 (0.8)	399 (18.9)	491 (23.3)	725 (34.3)	479 (22.7)
MsPGN	$36.34 \pm 15.53$	838 (8.0)	48 (5.7)	267 (31.9)	260 (31.0)	190 (22.7)	73 (8.7)
FSGS	$28.49 \pm 14.96$	486 (4.6)	18 (3.7)	126 (25.9)	181 (37.3)	117 (24.1)	44 (9.1)
MCD	$35.14 \pm 17.84$	386 (3.7)	35 (9.1)	147 (38.1)	87 (22.5)	67 (17.4)	50 (13.0)
IgMN	$31.39 \pm 14.03$	168 (1.6)	14 (8.3)	71 (42.3)	46 (27.4)	31 (18.5)	6 (3.6)
SCGN	$38.92 \pm 15.34$	120 (1.1)	6 (5.0)	30 (25.0)	44 (36.7)	27 (22.5)	13 (10.8)
CreGN	$45.41 \pm 16.69$	76 (0.7)	0 (0)	17 (22.4)	18 (23.7)	21 (27.6)	20 (26.3)
EnPGN	$23.69 \pm 18.49$	70 (0.7)	37 (52.9)	13 (18.6)	8 (11.4)	5 (7.1)	7 (10.0)
MPGN	$49.56 \pm 15.89$	66 (0.6)	2 (3.0)	10 (15.2)	9 (13.6)	25 (37.9)	20 (30.3)
HSPN	$24.91 \pm 15.15$	819 (7.8)	215 (26.3)	371 (45.3)	130 (15.9)	62 (7.6)	41 (5.0)
LN	$35.14 \pm 13.65$	675 (6.4)	23 (3.4)	243 (36.0)	231 (34.2)	146 (21.6)	32 (4.7)
DN	$54.03 \pm 9.78$	401 (3.8)	0 (0)	7 (1.8)	51 (12.7)	214 (53.4)	129 (32.2)
HTN	$45.34 \pm 13.15$	238 (2.3)	0 (0)	28 (11.8)	93 (39.1)	75 (31.5)	42 (17.7)
HBVN	$42.31 \pm 13.65$	165 (1.6)	2 (1.2)	31 (18.8)	59 (35.8)	56 (33.9)	17 (10.3)
Renal amyloidosis	$58.88 \pm 9.01$	158 (1.5)	0 (0)	0 (0)	9 (5.7)	73 (46.6)	76 (48.1)
SVARD	$58.45 \pm 13.38$	123 (1.2)	0 (0)	5 (4.1)	14 (11.4)	32 (26.0)	72 (58.5)
TIN	$45.96 \pm 14.85$	216 (2.1)	2 (0.9)	35 (16.2)	59 (27.3)	73 (33.8)	47 (21.8)

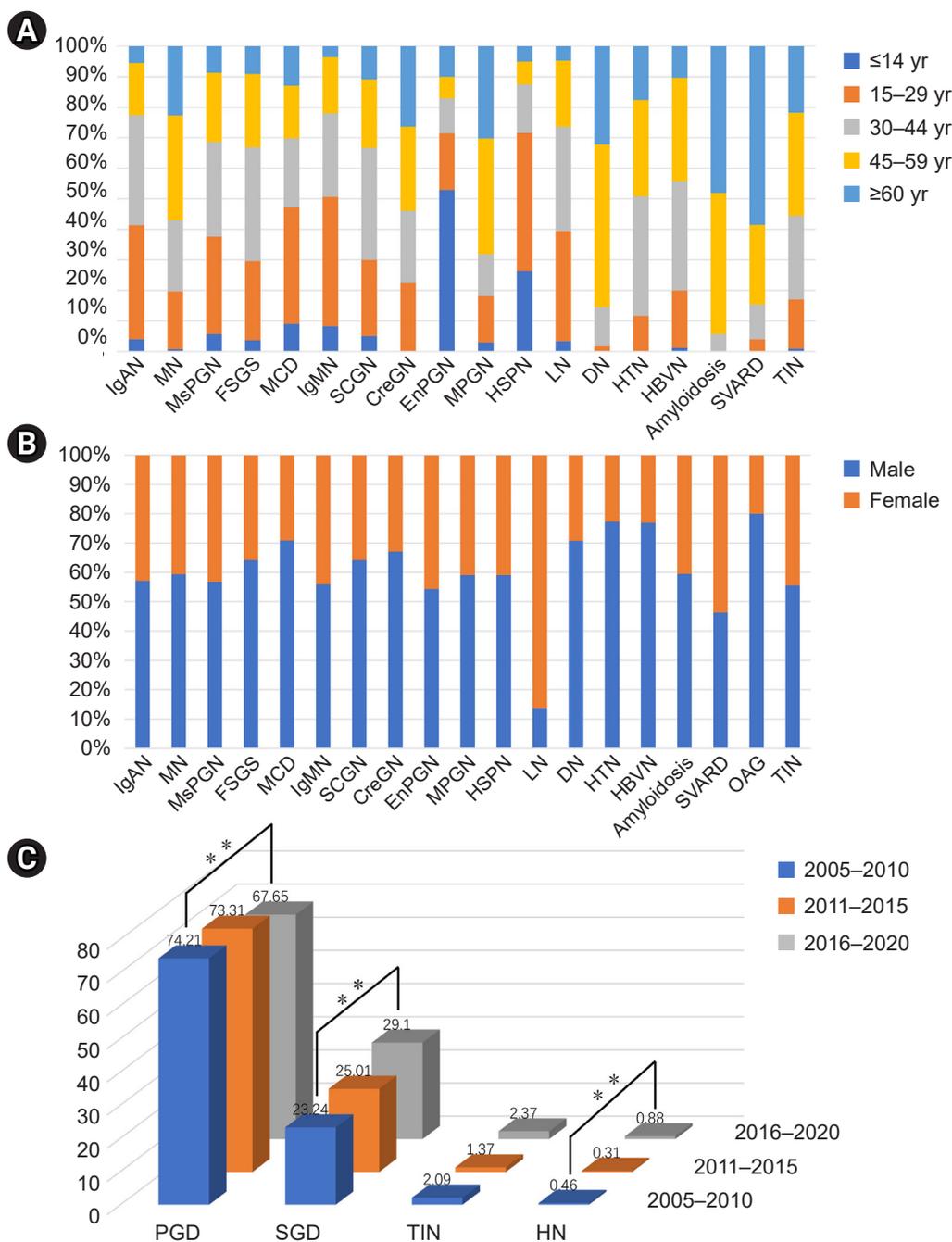
Data are expressed as number (%) and mean  $\pm$  standard deviation.

CreGN, crescentic glomerulonephritis; DN, diabetic nephropathy; EnPGN, endocapillary proliferative glomerulonephritis; FSGS, focal segmental glomerulosclerosis; HBVN, hepatitis B associated nephropathy; HSPN, Henoch-Schönlein purpura nephritis; HTN, hypertensive nephropathy; IgAN, immunoglobulin A nephropathy; IgMN, immunoglobulin M nephropathy; LN, systemic lupus erythematosus nephritis; MCD, minimal change disease; MN, membranous nephropathy; MPGN, membranoproliferative glomerulonephritis; MsPGN, mesangial proliferative glomerulonephritis; SCGN, sclerosing glomerulonephritis; SVARD, systemic vasculitis-associated renal damage; TIN, tubulointerstitial nephritis.

**Table 3.** Characteristics of age distribution in different periods

Period	Total	Average age (yr)	Age group (yr)				
			≤14	15–30	31–45	46–60	>60
1	2,258 (21.5)	$34.34 \pm 16.19$	190 (8.4)	852 (37.7)	645 (28.6)	392 (17.4)	179 (7.9)
2	3,926 (37.3)	$37.75 \pm 16.52$	245 (6.2)	1,314 (33.5)	1,072 (27.3)	877 (22.3)	418 (10.8)
3	4,344 (41.3)	$41.93 \pm 16.07$	128 (3.0)	1,120 (25.8)	1,240 (28.6)	1,217 (28.0)	639 (14.7)
Total	10,528	$38.73 \pm 16.53$	563 (5.4)	3,286 (31.2)	2,957 (28.1)	2,486 (23.6)	1,236 (11.7)

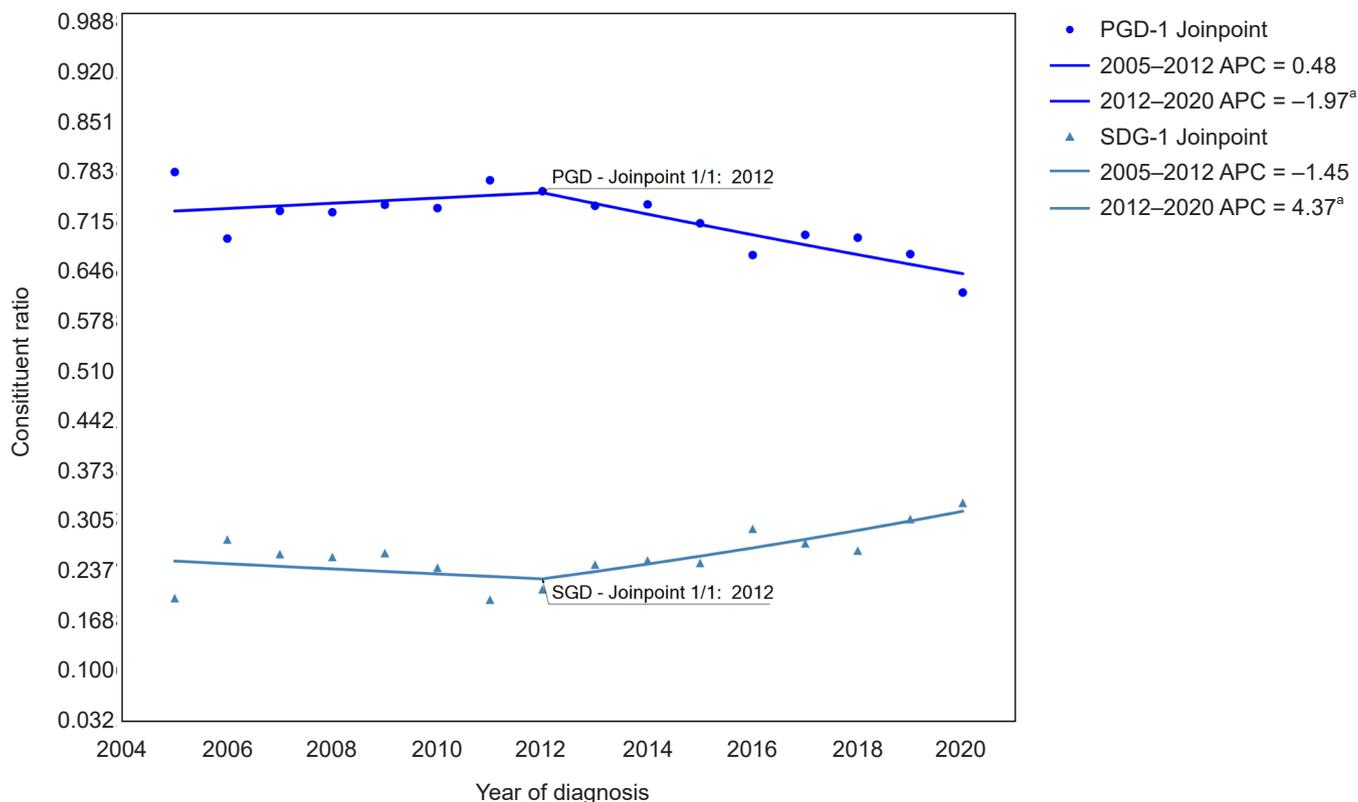
Data are expressed as number (%) and mean  $\pm$  standard deviation.



**Figure 1. The distribution of kidney biopsy based on different age groups and genders.** (A) The age distribution according to pathological findings. (B) The gender distribution according to pathological findings. (C) Changes in the constituent ratio of kidney biopsy disease spectrum in different periods.

CreGN, crescentic glomerulonephritis; DN, diabetic nephropathy; EnPGN, endocapillary proliferative glomerulonephritis; FSGS, focal segmental glomerulosclerosis; HBVN, hepatitis B associated nephropathy; HN, hereditary nephropathy; HSPN, Henoch-Schönlein purpura nephritis; HTN, hypertensive nephropathy; IgAN, immunoglobulin A nephropathy; IgMN, immunoglobulin M nephropathy; LN, systemic lupus erythematosus nephritis; MCD, minimal change disease; MN, membranous nephropathy; MPGN, membranoproliferative glomerulonephritis; MsPGN, mesangial proliferative glomerulonephritis; OAG, obesity-associated glomerulopathy; PGD, primary glomerular disease; SCGN, sclerosing glomerulonephritis; SGD, secondary glomerular disease; SVARD, systemic vasculitis-associated renal damage; TIN, tubulointerstitial nephritis.

\*\*p < 0.01.



**Figure 2. Changes in the constituent ratio of kidney biopsy disease spectrum.**

APC, annual percentage change; PGD, primary glomerular disease; SGD, secondary glomerular disease.

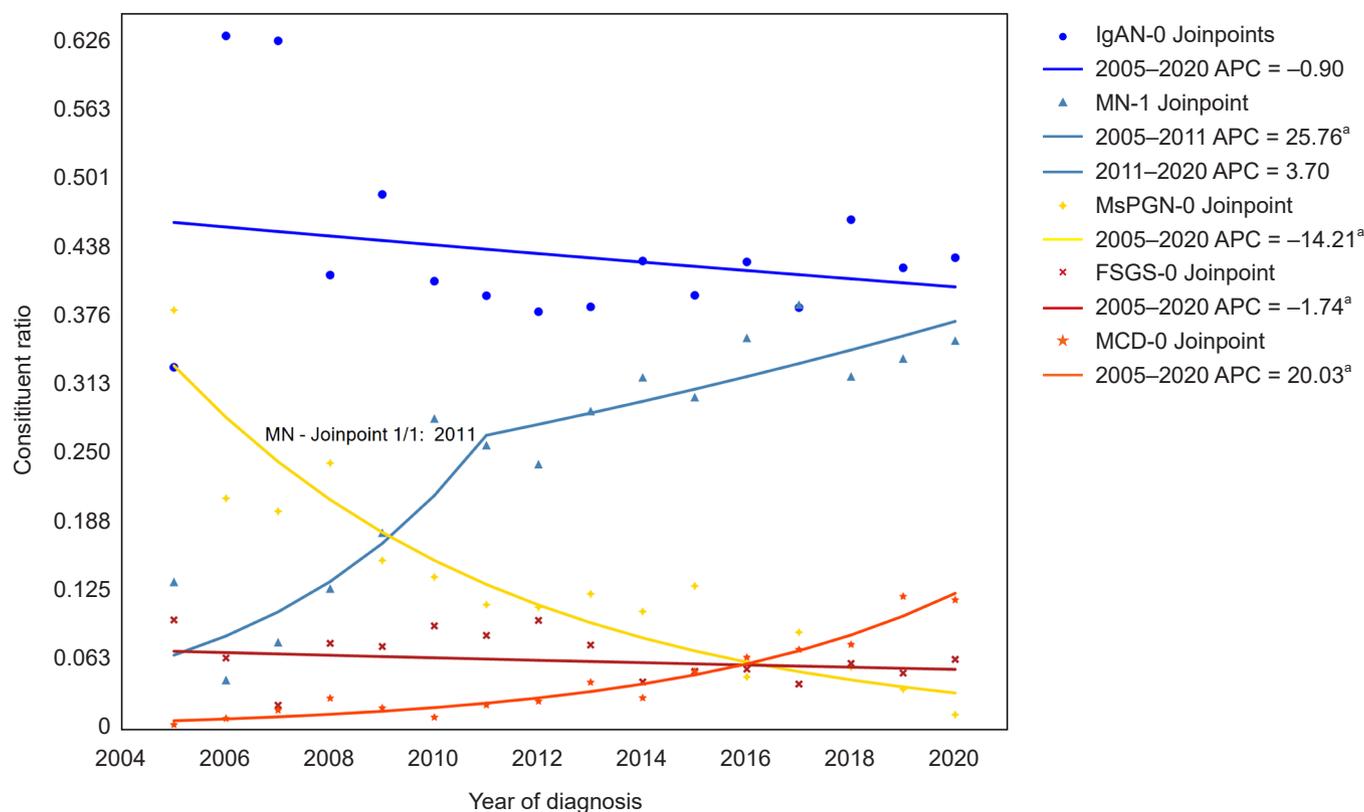
<sup>a</sup>APC is significantly different from zero at the  $\alpha = 0.05$  level.

### Changes in the constituent ratio of the kidney biopsy disease spectrum

According to the constituent ratio analysis of all cases grouped by period (Fig. 1C), the proportion of SGD increased significantly from 23.2% (period 1) to 29.1% (period 3), whereas that of PGD decreased relatively from 74.2% (period 1) to 67.7% (period 3). In the multiple joinpoint models, a key joinpoint came in 2012 (Fig. 2). In summary, the proportions of PGD and SGD fluctuated steadily from 2005 to 2012, with APC values of 0.5% (95% confidence interval [CI], -1.1 to 2.1;  $p = 0.51$ ) and -1.5% (95% CI, -5.8 to 3.1;  $p = 0.496$ ), respectively. Nevertheless, from 2012 to 2020, the APC of PGD changed to -2.0% (95% CI, -3.2 to -0.7;  $p = 0.01$ ), whereas that of SGD was 4.4% (95% CI, 0.6–8.3;  $p = 0.03$ ) (Supplementary Table 2, 3, available online), indicating that the proportion of PGD showed an obvious downward trend after 2012, while SGD showed an obvious upward trend.

### Trend analysis of the constituent ratio of the common type of primary glomerular disease

IgAN was the most common type of PGD during the study period, whereas the proportion showed a decreasing trend (Fig. 3) (APC, -0.9%; 95% CI, -2.9 to 1.1;  $p = 0.35$ ) (Supplementary Table 4, 5, available online). A downward trend was also shown for MsPGN (APC, -14.2%; 95% CI, -17.8 to -10.4;  $p < 0.001$ ) and FSGS (APC, -1.7%; 95% CI, -6.2 to 2.9;  $p = 0.43$ ). MN and MCD presented an increasing trend, of which MN was divided into two segments (2005–2011: APC, 25.8%; 95% CI, 6.3–48.7;  $p = 0.01$ ; 2011–2020: APC, 3.7%; 95% CI, -5.3 to 13.5;  $p = 0.40$ ). Despite the growth rate of MN slowing down after 2011, MN had the most significant growth trend both in terms of constituent ratio and the number of patients, and MCD showed a continuous increase (2005–2020; APC, 20.0%; 95% CI, 15.3–25.0;  $p < 0.001$ ).



**Figure 3. Trend analysis of the constituent ratio of common primary glomerular disease.**

APC, annual percentage change; FSGS, focal segmental glomerulosclerosis; IgAN, immunoglobulin A nephropathy; MN, membranous nephropathy; MsPGN, mesangial proliferative glomerulonephritis; MCD, minimal change disease.

<sup>a</sup>APC is significantly different from zero at the alpha = 0.05 level.

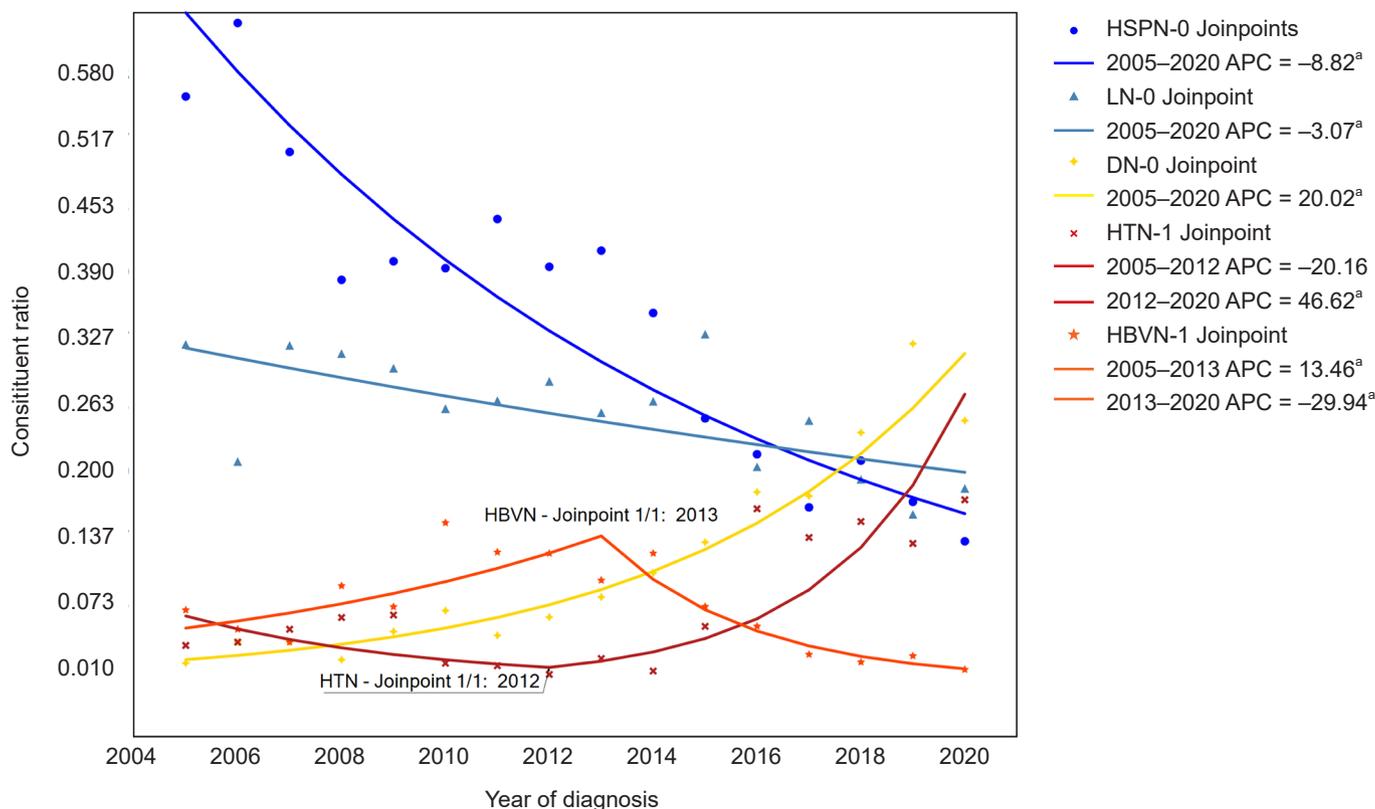
### Trend analysis of the constituent ratio of the common type of secondary glomerular disease

HSPN was the most common type of SGD with the highest proportion (29.9%). Nevertheless, the proportion of HSPN showed an obvious downward trend (Fig. 4) (2005–2020; APC, -8.8%; 95% CI, -10.6 to -7.0;  $p < 0.001$ ) (Supplementary Table 6, 7, available online). LN also showed a significant downward trend (2005–2020; APC, -3.1%; 95% CI, -5.0 to -1.1;  $p < 0.001$ ). Meanwhile, DN and HTN showed a huge growth trend over time, with APC achieving 20.0% (2005–2020; 95% CI, 16.4–23.7;  $p < 0.001$ ) and 46.6% (2012–2020; 95% CI, 18.3–81.7;  $p = 0.002$ ), respectively. Since 2018, DN has become the most common type of SGD. Another notable change in trend appeared for HBVN, with a clear joinpoint in 2013. From 2005 to 2013, there was a significant upward trend (APC, 13.5%; 95% CI, 2.2–26;  $p = 0.02$ ), whereas a continuous declining trend manifested thereaf-

ter (APC, -29.9%; 95% CI, -38.4 to -20.4;  $p < 0.001$ ).

### The relationship between pathological diagnosis and clinical diagnosis

The indications for kidney biopsy mainly included AUA (14.1%), CNS (51.6%), NS (30.0%), AKI (3.9%), RPG (0.3%), and others (0.2%). MN (47.3%) was the dominant cause of NS, followed by MsPGN (10.1%) (Supplementary Table 8, available online). From the age-stratified comparative analysis of indications for kidney biopsy (Supplementary Table 9, available online), AUA had an obvious distribution peak in the 15–30-year age group (48.7%). On the other hand, most clinical manifestations of MCD (73.8%), MN (70.8%), and renal amyloidosis (67.7%) were NS. The major complications in our group were hypertension (29.9%), hyperlipidemia (37.6%), and renal anemia (10.1%). In addition to HTN, hypertension was the main complication of



**Figure 4.** Trend analysis of the constituent ratio of common secondary glomerular disease.

APC, annual percentage change; DN, diabetic nephropathy; HBVN, hepatitis B associated nephropathy; HSPN, Henoch-Schönlein purpura nephritis; HTN, hypertensive nephropathy; LN, systemic lupus erythematosus nephritis.

<sup>a</sup>APC is significantly different from zero at the  $\alpha = 0.05$  level.

DN (80.1%), SCGN (68.3%), and MPGN (51.5%). Hyperlipidemia was the main complication of MN (76.2%), MCD (75.1%), and renal amyloidosis (69.0%). Renal anemia was the main complication of SVARD (52.0%), SCGN (40.8%), and DN (37.9%).

## Discussion

This report selected the largest kidney disease center in Northwest China for epidemiological statistical data from 10,528 kidney biopsy patients. The descriptive results of kidney biopsies indicated that kidney disease in Northwest China is more common among the young and middle-aged populations, and the age of onset is increasing. During the study period, the composition ratio of various pathological types changed significantly.

PGD was the most common kidney disease in this study, which is consistent with the data from other centers includ-

ing East [12–14], Central [15], and South [16] China (ranging from 65.1% to 71.1%). It is also the main kidney disease in East Asia in countries such as South Korea and Japan [5,17]. Conversely, in Western countries such as the United States and the United Kingdom, there was a higher proportion of SGD [2,18]. Interestingly, we indicated an obvious upward trend in SGD, which may reflect the evolution of the renal disease spectrum from developing countries to developed countries under the context of rapid economic growth and urbanization. In the specific analysis of PGD, we identified that IgAN still accounted for the highest proportion. This is consistent with the report from East Asia in countries [17,19] such as Japan and South Korea, as well as some other international data (Spain, Czech Republic, Denmark, Italy, Scotland, Kuwait, and Turkey) [6,20–22]. FSGS showed the highest proportion in Europe [22] and MPGN showed the highest proportion in South Africa [15]. In addition to the findings in our research, a decreasing trend in IgAN

was also observed in Northeast [12], South [16], and Central [15] China, which may be due to the sudden increase in MN morbidity and the gradual rise in SGD rates.

MN was the disease with the second greatest incidence in our study, and the majority of patients were middle-aged and elderly (>45 years, 57.0%). The rapid growth of MN not only appears in Northwest China, but also in other regions of the country [14,15,23], and has attracted the attention of researchers. In addition to ethnic or genetic factors, a lot of attention has been focused on environmental effects. Air pollution increases the circulating levels of inflammatory mediators, such as tumor necrosis factor- $\alpha$ , interleukin-6, and plasminogen activator inhibitor-1, and genetic polymorphisms in these cytokines are associated with the development of MN [24]. In a large kidney biopsy series in China [23] and India [25], researchers found that the increased frequency of MN was associated with long-term exposure to high levels of particulate matter less than 2.5  $\mu\text{m}$  (PM2.5). In contrast, in developed countries with lower PM2.5 exposure levels, such as Japan [5], Korea [19], France [26], and the United States [9], the MN prevalence has remained stable or even reversed [24]. Regarding current trends, MN has already become the most common type of PGD in some parts of China with high PM2.5 levels [14,15,23]. Judging from the trend chart, coupled with the aggravation of air pollution, the frequent occurrence of haze, and the increase in PM2.5 pollution in Northwest China [27], the prevalence of MN may further increase. This is probably the most notable change in the spectrum of kidney disease in Northwest China.

In regards to the pathological types of SGD, HSPN ranked first in Northwest China and was significantly higher than in other regions of China [7,15,16]. The pathological data of kidney biopsies in Gansu Province also showed that the proportion of HSPN in SGD was the highest (26.1%) [28]. Therefore, it is reasonable to suggest that a high incidence of HSPN is a prominent feature in Northwest China. Intensive exposure to dust weather and other allergic factors in this area, which have a stronger pro-inflammatory effect and cause acute irritant effects on human health including some severe allergic reactions, may contribute to this epidemic character [28,29]. Although the number of HSPN cases remained at a high level, the composition ratio showed a downward trend. This may be related to the significant increase in other types of SGD. LN was the sec-

ond most common form of SGD in our data and showed a downward trend. However, in Central, Eastern, and Southern China, LN remains the most common form of SGD [13,15,16]. The high incidence of LN is indeed a significant feature of SGD in China.

HTN had the highest growth rate in our study, which was in line with that of Japan and Korea [17]. China has approximately 270 million people with high blood pressure, making it the country with the largest absolute burden of hypertension in the world, and the prevalence rate is increasing year by year [30]. Currently, the proportion of HTN in patients with ESKD varies among different countries [31]. The incidence of HTN will undoubtedly increase in the future with the aging of the population and improvements in cardiovascular disease survival. However, the diagnosis of HTN at present is nonspecific and is mainly based on clinical manifestations [32]. Several studies that have compared biopsy-proven HTN with clinical HTN have found that the former could not be distinguished from renal damage caused by PGD, and the misdiagnosis rate was more than half [33,34]. To avoid misdiagnosis, the biopsy rate of HTN should be further improved. The diagnostic policy of DN is similar to that of HTN at present, and often only a kidney biopsy will make a differential diagnosis possible [35]. Although the detection rate of DN may be underestimated, we have found that it has become the most common type of SGD since 2018. According to the 2019 Scientific Report of Kidney Disease in China, DN has become the leading cause of CKD in hospitalized patients in China, as well as HTN [2]. In addition, in less-developed regions such as Northwest China, hypertension and diabetes are also highly prevalent and poorly managed due to low awareness, treatment, and control rates [36]. Therefore, there is much to be done in improving the diagnosis and management of hypertension and diabetes.

A change in the proportion of HBVN was also noted. The global prevalence of chronic hepatitis B is serious, particularly in certain developing countries, including China [37]. Western China has the highest incidence of hepatitis B in the country [38]. In a jointpoint analysis using hepatitis B morbidity and mortality data from the China Data Center for Public Health Sciences and demographic data from the National Bureau of Statistics, the reported incidence reached an inflection point in 2006 [37]. Our data reflects the epidemic profile of the disease from one side. The

proportion of HBVN showed a peak in 2013, which may be attributed to the control of hepatitis B infection and the widespread use of the hepatitis B vaccine in China. As expected, the population affected by and constituent ratio of HBVN should decrease further.

In our study, CNS was the most common clinical indication for kidney biopsy, followed by NS. Due to inconsistencies in clinical indication and variation in renal biopsy policies in different regions, the conclusions also varied, such as in Japan (CNS, followed by NS), South Korea (AUA, followed by NS), Turkey (NS, followed by AUA), and Central China (NS, followed by CNS) [15,22]. However, NS is generally considered to be the most important indicator for biopsy, and MCD is the most common form of NS in children whereas MN is the most common form in adults [39]. In Japan, approximately 40% of patients with primary NS are diagnosed with MCD [5]. In contrast to the management of NS in adults, a diagnostic kidney biopsy is generally not performed upon presentation in children to establish a diagnosis [39]. Therefore, the proportion of MCD in patients with NS may be underestimated.

The high incidence of hypertension in our study reflected a significant impact on prognosis. The Kidney Disease: Improving Global Outcomes (KDIGO) 2021 Clinical Practice Guideline for the Management of Blood Pressure in CKD reemphasizes the importance of blood pressure management [40]. Renal anemia is a common clinical manifestation of CKD, which increases the risk of ESKD, cardiovascular events, and death [41]. In addition to vascular inflammatory nephropathies such as SVARD and SCGN, DN is most associated with renal anemia. Anemia in DN not only occurs early and seriously but also promotes the progression of DN and induces and aggravates diabetic complications.

This study provides information about the latest epidemic spectrum of kidney disease in Northwest China, which is expected to provide a basis for public health prevention and therapeutic strategy. Generally, kidney disease is more common among the young and middle-aged populations, and the age of onset is increasing. PGD accounted for most cases of kidney disease in this group. The proportion of SGD increased while PGD declined. IgAN remained the most common pathological type, while MN significantly increased. HSPN was the most common pathological type of SGD and could be a hallmark of Northwest China. DN

showed the most obvious increasing trend in types of SGD from the analysis, whereas the fastest growth since 2012 was in HTN. Moreover, HBVN showed a joinpoint from increase to decrease. The spectrum changes of kidney disease, especially the constituent ratio of SGD, pose a great challenge to public health.

### Conflicts of interest

All authors have no conflicts of interest to declare.

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### Data sharing statement

The data presented in this study are available on request from the corresponding author.

### Authors' contributions

Conceptualization: SS  
 Data curation: YQ, JZ, ZY  
 Formal analysis: YQ, YW, ZY, YZ  
 Funding acquisition: SS  
 Methodology: XW  
 Project administration: SS  
 Software: YQ, XW  
 Writing—original draft: YQ  
 Writing—review & editing: SS, JZ, ZY, YZ  
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