e-ISSN: 2988-3237
Vol. 4 No. 2 (2026): 152–162

ORIGINAL ARTICLE

Sex-Stratified Sociodemographic and Clinical Profile of Maintenance Hemodialysis Patients at a Remote Island Hospital in Bali: A Cross-Sectional Study

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ARTICLE INFO

Article history

Received: July 22, 2026

Revised: August 20, 2026

Accepted: September 18, 2026

Available online: September 25, 2026

Published: September 27, 2026

Keywords:

Arteriovenous fistula
Hemodialysis
Indonesia
Kidney failure, chronic
Sex factors

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DOI

https://doi.org/10.59345/sjim.v4i2.346

ABSTRACT

Background: Chronic kidney disease is a growing burden in Indonesia, yet the hemodialysis population of small remote islands is undescribed, and whether reported sex disparities appear there is unknown.

Objective: To profile, by sex, all maintenance hemodialysis patients at an island hospital on Nusa Penida, Bali, and to benchmark key indicators against national and regional reference populations.

Methods: This retrospective cross-sectional study included all 31 patients with stage 5 chronic kidney disease on maintenance hemodialysis in January–March 2026. Proportions with 95% Wilson intervals were compared with benchmarks by exact binomial tests; sex differences used Fisher exact tests with Holm correction. Other bivariate associations and Firth multivariable models for catheter use, hemoglobin ≤10 g/dL and non-employment were analyzed across all datasets consistent with the observed counts.

Results: Sixteen patients (51.6%) were women; 58.1% were aged ≥51 years. Hypertensive nephrosclerosis was the recorded etiology in 58.1% (95% CI 40.8–73.6), 41.9% were dialyzed through a double-lumen catheter, 61.3% had hemoglobin ≤10 g/dL, 71.0% were not employed, and none was HBsAg-positive. Fistula use was lower than in Chinese (84.7%) and Japanese (90.7%) cohorts (Holm-adjusted $p \leq 0.004$). Women less often had senior high school education or higher (18.8% vs 73.3%; Holm-adjusted $p = 0.042$). In multivariable models, female sex showed the largest adjusted association with non-employment (median OR 4.68), but no predictor was significant across all consistent datasets.

Conclusion: Patients were mostly aged 51–70 years, largely unemployed, and frequently catheter-dependent and anemic, with a pronounced educational disadvantage among women; a patient-level registry should address the access and anemia gaps identified.

1. Introduction

Chronic kidney disease (CKD) is a leading and growing contributor to morbidity, mortality and health expenditure in low- and middle-income countries, and Indonesia carries a substantial share of this burden. Analyses of the 2018 National Basic Health Survey place self-reported CKD prevalence in Indonesian adults at 0.38-–0.5%, with independent associations for diabetes, heart disease, male sex and low educational attainment, and with more than three-fold variation between provinces[1,2]. Globally, the incidence of CKD attributable to hypertension rose by 63.9% between 1990 and 2021[3], and rural populations are the most frequently reported subnational CKD hotspots in a survey of 162 countries[4]. For patients who reach kidney failure, hemodialysis is the dominant form of kidney replacement therapy in Indonesia; CKD ranks second in national health insurance expenditure, and hemodialysis is its largest cost component[5].

The Indonesian Renal Registry now provides a national picture of this population. Among 122,449 patients receiving hemodialysis between 2016 and 2019, the mean age was 52 years, 55.5% were men and hypertensive kidney disease was the most frequently recorded etiology (43.7%); one-year survival was 91.5%, and five-year survival among 99,552 adults was 77%[6,7]. The same registry identified modifiable, service-level predictors of death: initiation through a central venous catheter was associated with a hazard ratio of 2.99 for five-year mortality, femoral puncture with 2.71, and twice-weekly rather than thrice-weekly hemodialysis with 1.08[7]. Similar gradients for catheter access, dialysis frequency and low hemoglobin have been reported from national registries in Thailand and Japan and from a 15-year Pakistani cohort[8-–10]. Vascular access type and hemoglobin level are therefore not merely descriptive attributes: they are quality markers with established prognostic weight.

Who reaches hemodialysis, and on what terms, is shaped by sex, socioeconomic position and geography. Women constitute only 35-–41% of incident kidney replacement populations in Europe, the United States and Korea, and the male-to-female initiation ratio in Australia has widened over five decades[11-–13]. Once on dialysis, women face lower fistula maturation and greater catheter dependence[14,15], and in an Indian nationwide network women were less educated, less often insured and more often dialyzed through temporary catheters[16]. Employment is frequently lost after dialysis starts, with only a quarter to a third of working-age patients remaining employed in European and Chinese cohorts[17,18]. In Indonesia, national insurance claims show that men, younger patients and residents of Java or Bali have markedly greater odds of receiving hemodialysis, with disparities most pronounced in rural areas[19].

Geographic isolation adds a further barrier. Most rural counties in the United States lack a dialysis facility[20], half of Brazilian patients travel more than 40 km to dialysis[21], and a

e-ISSN: 2988-3237
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study from a remote Japanese island documented a substantial burden of stroke, with poor survival after hemorrhagic stroke, among patients dialyzed there[22]. Nusa Penida is an island of Klungkung Regency separated from mainland Bali by sea, and before hemodialysis services were established at Gema Santi Nusa Penida Regional General Hospital, access for island residents with kidney failure was limited and required sea travel to mainland Bali. Indonesian evidence on hemodialysis populations, however, comes almost entirely from registries, insurance claims and tertiary referral centres in large cities[6,19,23,24]. A five-centre study in Jakarta that systematically documented primary kidney disease found diabetic kidney disease in 27.2%, hypertension in only 11.5% and an unknown cause in 31.1%[23], proportions that diverge sharply from the hypertension-dominant attribution recorded in the registry.

No study has described the patients treated in a hemodialysis unit on a small Indonesian island, and none has examined whether the sex disparities reported internationally are visible in such a setting. Descriptive series from single Indonesian units have also tended to present proportions without measures of uncertainty, which makes it impossible to judge whether a "predominant" category is distinguishable from its alternatives[25]. This study therefore aimed (1) to describe the sociodemographic and clinical characteristics of all patients receiving maintenance hemodialysis at Gema Santi Nusa Penida Regional General Hospital, with interval estimates; (2) to compare these characteristics between women and men; (3) to benchmark key indicators — sex distribution, recorded etiology, vascular access, employment and hepatitis B status — against national and regional reference populations; and (4) to examine bivariate and multivariable associations among these characteristics.

2. Methods

2.1 Study design

This was a retrospective, single-centre, descriptive cross-sectional study based on review of existing medical records. It is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional studies.

2.2 Ethical approval

This study was approved by the Research Ethics Committee, Faculty of Medicine, Universitas Udayana, Denpasar, Indonesia (No. 2512/UN14.2.2.VII.14/LT/2026; protocol number 2026.03.1.0957). The study used anonymized medical records; individual informed consent was waived in accordance with institutional protocol. The study was conducted in accordance with the Declaration of Helsinki.

2.3 Setting

The study was conducted in the Hemodialysis Unit of Gema Santi Nusa Penida Regional General Hospital, the government hospital serving Nusa Penida island in Klungkung Regency, Bali Province, Indonesia. The unit provides outpatient maintenance hemodialysis to residents of the island, for whom the alternative is sea travel to hemodialysis facilities on mainland Bali. The records reviewed covered patients who received maintenance hemodialysis in the unit between January and March 2026.

2.4 Participants and sampling

Total sampling was applied: every patient treated in the unit during the study window who met the eligibility criteria was included, so no sample size calculation was performed. Inclusion criteria were a diagnosis of stage 5 CKD documented in the medical record, receipt of maintenance (regular, scheduled) hemodialysis in the unit, and a medical record that was complete for the study variables. Patients with acute conditions unrepresentative of the maintenance hemodialysis population were excluded. Thirty-one patients met the criteria and were analyzed.

2.5 Variables and definitions

Data were abstracted from medical records into a standardized data collection form and entered into Microsoft Excel. Nine variables were collected. **Sex** was recorded as male or female. **Age** was recorded in ten-year bands (21-–30, 31-–40, 41-–50, 51-–60, 61-–70 and 71-–80 years). **Educational attainment** was the highest completed level: no formal education, elementary school, junior high school, senior high or vocational high school, diploma, or bachelor's degree. **Employment status** was classified as employed or not employed; the latter comprised all patients without paid work. **Marital status** was recorded as married or unmarried.

Hemodialysis vintage was the total time since the start of maintenance hemodialysis, grouped as <1 year, 1-–5 years and >5 years; it included any hemodialysis received before transfer to the island unit. **Etiology of CKD** was the primary kidney disease documented in the medical record and was grouped as hypertensive nephrosclerosis, diabetic nephropathy, chronic pyelonephritis, lupus nephritis, obstructive uropathy or uric acid nephropathy. **Vascular access** was the access documented in the medical record, recorded as an arteriovenous fistula (documented locally as an "AV shunt") or a double-lumen hemodialysis catheter (hereafter, catheter). **Hepatitis B surface antigen (HBsAg)** status was the result documented in the record. **Hemoglobin** was the value documented in the record, categorized as <7, 7-–10 or >10 g/dL. Vascular access, HBsAg status and hemoglobin were taken from the documentation for the study window.

2.6 Statistical analysis

The unit of analysis was the patient. Each variable was recorded as the number of patients per category within women and within men. Analyses were organized into univariate, bivariate and multivariable layers; associations not involving sex were analyzed over all patient-level datasets consistent with these sex-specific counts, as a sensitivity analysis.

Univariate analysis. Each proportion was reported with a 95% Wilson score confidence interval (CI), which retains nominal coverage at small sample sizes and near 0% or 100%. Whether the most frequent category of each variable exceeded half of the cohort was tested with an exact binomial test against 50%, and whether it was more frequent than the second most frequent category with an exact conditional binomial test. The median category of each ordinal variable was identified from the cumulative distribution. Precision was summarized as the width of the 95% CI at the observed proportions and the number of patients required for ±10 and ±5 percentage-point precision.

Benchmark comparisons. Key proportions were compared with reference proportions taken from published studies identified in a structured literature search: the Indonesian Renal Registry for sex distribution and hypertensive etiology[6], a Jakarta multicentre study for systematically documented etiology[23], Chinese, Japanese and Tanzanian cohorts for arteriovenous fistula use[9,26,27], European and Chinese cohorts for employment[17,18], a Riau study for marital status and education[25], and Saudi, Pakistani and Chinese cohorts for HBsAg positivity[28-–30]. Each comparison used a two-sided exact one-sample binomial test with the reference value treated as fixed, Holm's procedure controlled the family-wise error rate across the 15 comparisons, and the magnitude of difference was expressed as Cohen's h (0.2 small, 0.5 medium, 0.8 large). Treating the reference as fixed ignores its own sampling error, which is negligible for registry populations but not for smaller series such as Riau (n=30) and Tanzania (n=200). The reference populations also differ from this cohort in design — incident rather than prevalent patients in Korea, working-age restriction in Beijing and Europe, and tertiary centres including transplant recipients in Jakarta — so the comparisons indicate whether this cohort departs from each published profile rather than estimating a like-for-like difference.

Bivariate analysis by sex. The distribution of each variable was compared between women and men with the Fisher–Freeman–Halton exact test, with Cramér's V as the effect size. For ordinal variables (age, education, hemodialysis vintage and hemoglobin), Cliff's delta was calculated, with tied pairs contributing zero, and tested with a two-sided permutation test (200,000 permutations). Eleven binary contrasts of clinical interest were defined before the analysis was run — catheter use, non-employment, age ≤40 years, age ≤50 years, no or elementary education, senior high school education or higher, hemoglobin ≤10 g/dL, vintage <1 year, and hypertensive nephrosclerosis, lupus nephritis and chronic pyelonephritis as etiology — and each was summarized as an odds ratio (OR; female versus male) with a Woolf 95% CI (Haldane–Anscombe correction when a cell was zero), a risk difference with 95% CI, Cohen's h and a two-sided Fisher exact p value. Holm's step-down procedure controlled the family-wise error rate across the 11 contrasts.

Bivariate analysis between other variables. For 11 pairs involving vascular access, hemoglobin, hemodialysis vintage, age, etiology, education and employment, every non-negative integer 2×2 table compatible with the observed counts within women and within men was enumerated. For each admissible table the OR (Haldane–Anscombe corrected), Fisher exact p value, Cramér's V and risk difference were computed, and the attainable minimum and maximum of each measure were reported. The share of admissible patient-level datasets with p<0.05 was obtained by weighting each table by the number of patient arrangements producing it, which corresponds to within-sex independence. Ordinal exposures were examined with the Cochran–Armitage trend test (scores 0, 1, 2, ...) across all admissible allocations. An attainable range that included the null value indicated that the association is not identifiable from the observed counts; a range excluding it would indicate a result holding in every consistent dataset.

Multivariable analysis. Three Firth-penalized logistic regression models were fitted: catheter use (13 events) with female sex, vintage <1 year, age ≤50 years and etiology other than hypertensive nephrosclerosis; hemoglobin ≤10 g/dL (19 events) with female sex, catheter use, vintage <1 year and etiology other than hypertensive nephrosclerosis; and non-employment (22 events) with female sex, age >50 years and no or elementary education. For each model, 5,000 admissible patient-level datasets were generated by permuting each variable independently within sex, which preserves every observed count, and the model was fitted to each. Results are summarized as the median adjusted OR with its 2.5th-–97.5th percentile band across datasets, the percentage of datasets in which the predictor reached p<0.05, and the attainable range located by hill-climbing (20 restarts of 300 value swaps per direction). Firth penalization was used because separation is expected at this sample size.

All tests were two-sided with α=0.05, and p values are reported to three decimal places. Data entry and frequency tabulation used Microsoft Excel and IBM SPSS Statistics version 21.0; all interval estimation, exact and permutation tests, enumeration and penalized regression were performed in Python 3 (SciPy 1.18, statsmodels 0.15 and NumPy) with fixed random seeds, and the analysis code is available from the corresponding author on request. Sample sizes for future comparisons were calculated for a two-sided comparison of two proportions using the arcsine transformation, with α=0.05 and 80% power.

3. Results

3.1 Study population and sociodemographic characteristics

Thirty-one patients receiving maintenance hemodialysis were included: 16 women (51.6%, 95% CI 34.8-–68.0) and 15 men (48.4%). The sex distribution did not differ from parity (exact binomial p=1.000; Cohen's h=0.03). The sociodemographic and clinical characteristics of the cohort, overall and by sex, are presented in Table 1.

Table 1. Sociodemographic and clinical characteristics of patients receiving maintenance hemodialysis, overall and by sex.

Characteristic	All (n = 31), n (%) [95% CI]	Male (n = 15), n (%)	Female (n = 16), n (%)	p*	Cramér's V
Age, years				0.157	0.47
21–30	2 (6.5) [1.8–20.7]	0 (0.0)	2 (12.5)		
31–40	3 (9.7) [3.3–24.9]	0 (0.0)	3 (18.8)		
41–50	8 (25.8) [13.7–43.2]	6 (40.0)	2 (12.5)		
51–60	14 (45.2) [29.2–62.2]	7 (46.7)	7 (43.8)		
61–70	4 (12.9) [5.1–28.9]	2 (13.3)	2 (12.5)		
71–80	0 (0.0) [0.0–11.0]	0 (0.0)	0 (0.0)		
Educational attainment				0.030	0.60
No formal education	6 (19.4) [9.2–36.3]	2 (13.3)	4 (25.0)		
Elementary school	9 (29.0) [16.1–46.6]	2 (13.3)	7 (43.8)		
Junior high school	2 (6.5) [1.8–20.7]	0 (0.0)	2 (12.5)		
Senior/vocational high school	10 (32.3) [18.6–49.9]	8 (53.3)	2 (12.5)		
Diploma	2 (6.5) [1.8–20.7]	1 (6.7)	1 (6.3)		
Bachelor's degree	2 (6.5) [1.8–20.7]	2 (13.3)	0 (0.0)		
Employment status				0.054	0.38
Not employed	22 (71.0) [53.4–83.9]	8 (53.3)	14 (87.5)		
Employed	9 (29.0) [16.1–46.6]	7 (46.7)	2 (12.5)		
Marital status				—	—
Unmarried	0 (0.0) [0.0–11.0]	0 (0.0)	0 (0.0)		
Married	31 (100.0) [89.0–100.0]	15 (100.0)	16 (100.0)		
Hemodialysis vintage				0.430	0.25
<1 year	7 (22.6) [11.4–39.8]	2 (13.3)	5 (31.3)		

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Characteristic	All (n = 31), n (%) [95% CI]	Male (n = 15), n (%)	Female (n = 16), n (%)	p*	Cramér's V
1–5 years	18 (58.1) [40.8–73.6]	9 (60.0)	9 (56.3)		
>5 years	6 (19.4) [9.2–36.3]	4 (26.7)	2 (12.5)		
Recorded etiology of CKD				0.158	0.50
Lupus nephritis	2 (6.5) [1.8–20.7]	0 (0.0)	2 (12.5)		
Diabetic nephropathy	4 (12.9) [5.1–28.9]	3 (20.0)	1 (6.3)		
Obstructive uropathy	1 (3.2) [0.6–16.2]	0 (0.0)	1 (6.3)		
Hypertensive nephrosclerosis	18 (58.1) [40.8–73.6]	7 (46.7)	11 (68.8)		
Chronic pyelonephritis	5 (16.1) [7.1–32.6]	4 (26.7)	1 (6.3)		
Uric acid nephropathy	1 (3.2) [0.6–16.2]	1 (6.7)	0 (0.0)		
Vascular access				0.149	0.30
Arteriovenous fistula	18 (58.1) [40.8–73.6]	11 (73.3)	7 (43.8)		
Double-lumen catheter	13 (41.9) [26.4–59.2]	4 (26.7)	9 (56.3)		
HBsAg				—	—
Positive	0 (0.0) [0.0–11.0]	0 (0.0)	0 (0.0)		
Negative	31 (100.0) [89.0–100.0]	15 (100.0)	16 (100.0)		
Hemoglobin, g/dL				0.588	0.22
<7	1 (3.2) [0.6–16.2]	0 (0.0)	1 (6.3)		
7–10	18 (58.1) [40.8–73.6]	8 (53.3)	10 (62.5)		
>10	12 (38.7) [23.7–56.2]	7 (46.7)	5 (31.3)		

Percentages for male and female columns are within-sex. 95% CI, Wilson score interval. *Fisher–Freeman–Halton exact test comparing the distribution between women and men; — not computable because the variable was constant. CKD, chronic kidney disease; HBsAg, hepatitis B surface antigen.

Patients were aged between 21 and 70 years; no patient was older than 70 years. The 51-–60-year band was the most frequent (14 patients, 45.2%, 95% CI 29.2-–62.2) and contained the median patient both overall and in each sex. Eighteen patients (58.1%, 95% CI 40.8-–73.6) were aged 51 years or older. The 51-–60-year band was not distinguishable from the 41-–50-year band (8 patients, 25.8%; p=0.286). All five patients aged 40 years or younger were women (5/16, 31.3% of women vs 0/15 men), whereas six of the eight patients aged 41-–50 years were men.

Educational attainment was low. Fifteen patients (48.4%, 95% CI 32.0-–65.2) had no formal education or elementary schooling only, and the median patient had completed junior high school. Senior or vocational high school was the most frequent single level (10 patients, 32.3%, 95% CI 18.6-–49.9), but it was not more frequent than elementary schooling (9 patients, 29.0%; p=1.000). Only four patients (12.9%) held a diploma or bachelor's degree. Twenty-two patients (71.0%, 95% CI 53.4-–83.9) were not employed — the only sociodemographic category other than marital status to exceed half of the cohort (p=0.029). All 31 patients were married (100%, 95% CI 89.0-–100).

3.2 Clinical characteristics

Eighteen patients (58.1%, 95% CI 40.8-–73.6) had received hemodialysis for 1-–5 years, seven (22.6%, 95% CI 11.4-–39.8) for less than one year and six (19.4%, 95% CI 9.2-–36.3) for more than five years. The 1-–5-year group was more frequent than the <1-year group (p=0.043).

Hypertensive nephrosclerosis was the recorded etiology in 18 patients (58.1%, 95% CI 40.8-–73.6), followed by chronic pyelonephritis in five (16.1%, 95% CI 7.1-–32.6), diabetic nephropathy in four (12.9%, 95% CI 5.1-–28.9), lupus nephritis in two (6.5%, 95% CI 1.8-–20.7), and obstructive uropathy and uric acid nephropathy in one patient each (3.2%). Hypertensive nephrosclerosis was more frequent than chronic pyelonephritis (p=0.011). No etiology was recorded as unknown. Both patients with lupus nephritis and the patient with obstructive uropathy were women; four of the five patients with chronic pyelonephritis, three of the four with diabetic nephropathy and the patient with uric acid nephropathy were men.

Eighteen patients (58.1%) were dialyzed through an arteriovenous fistula and 13 (41.9%, 95% CI 26.4-–59.2) through a double-lumen catheter. All 31 patients were HBsAg-negative (0%, 95% CI 0.0-–11.0). Hemoglobin was 7-–10 g/dL in 18 patients (58.1%) and below 7 g/dL in one (3.2%), so that 19 patients (61.3%, 95% CI 43.8-–76.3) had hemoglobin of 10 g/dL or less; 12 (38.7%, 95% CI 23.7-–56.2) had hemoglobin above 10 g/dL. The median patient was in the 7-–10 g/dL band in both sexes.

The precision of these estimates was limited by the size of the cohort. At the observed proportion of 58.1%, the 95% CI spanned 32.8 percentage points; estimating a proportion to within ±10 percentage points would require 97 patients, and to within ±5 points, 385 patients.

3.3 Differences between women and men

Distributions by sex are compared in Table 1, and the binary contrasts defined before analysis are summarized in Table 2. Educational attainment differed by sex (Fisher–Freeman–Halton p=0.030; Cramér's V=0.60), with women concentrated at lower levels (Cliff's delta −0.49; permutation p=0.017; Supplementary Table S2). Three of 16 women (18.8%) had completed senior high school or higher, compared with 11 of 15 men (73.3%): an OR of 0.08 (95% CI 0.02-–0.46), a risk difference of −54.6 percentage points (95% CI −84.0 to −25.1) and a Cohen's h of −1.16 (p=0.004). This was the only contrast that remained significant after Holm correction (adjusted p=0.042). Conversely, 11 women (68.8%) and four men (26.7%) had no or elementary education only (OR 6.05, 95% CI 1.27-–28.73; p=0.032; Holm-adjusted p=0.320).

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Table 2. Binary contrasts between women and men defined before analysis.

Characteristic	Female, n/N (%)	Male, n/N (%)	OR† [95% CI]	Risk difference, points [95% CI]	Cohen's h	Fisher p	Holm p
Double-lumen catheter use	9/16 (56.3)	4/15 (26.7)	3.54 [0.78–16.03]	29.6 [−3.5 to 62.6]	0.61	0.149	1.000
Not employed	14/16 (87.5)	8/15 (53.3)	6.13 [1.02–36.89]	34.2 [4.2 to 64.2]	0.78	0.054	0.430
Age ≤40 years	5/16 (31.3)	0/15 (0.0)	14.83 [0.74–295.97]	31.3 [8.5 to 54.0]	1.19	0.043	0.390
Age ≤50 years	7/16 (43.8)	6/15 (40.0)	1.17 [0.28–4.87]	3.7 [−31.0 to 38.5]	0.08	1.000	1.000
No or elementary education only	11/16 (68.8)	4/15 (26.7)	6.05 [1.27–28.73]	42.1 [10.2 to 74.0]	0.87	0.032	0.320
Senior high school or higher	3/16 (18.8)	11/15 (73.3)	0.08 [0.02–0.46]	−54.6 [−84.0 to −25.1]	−1.16	0.004	0.042‡
Hemoglobin ≤10 g/dL	11/16 (68.8)	8/15 (53.3)	1.93 [0.44–8.33]	15.4 [−18.5 to 49.4]	0.32	0.473	1.000
Hemodialysis vintage <1 year	5/16 (31.3)	2/15 (13.3)	2.95 [0.48–18.34]	17.9 [−10.6 to 46.4]	0.44	0.394	1.000
Hypertensive nephrosclerosis	11/16 (68.8)	7/15 (46.7)	2.51 [0.58–10.88]	22.1 [−11.9 to 56.0]	0.45	0.285	1.000
Lupus nephritis	2/16 (12.5)	0/15 (0.0)	5.34 [0.24–121.00]	12.5 [−3.7 to 28.7]	0.72	0.484	1.000
Chronic pyelonephritis	1/16 (6.3)	4/15 (26.7)	0.18 [0.02–1.88]	−20.4 [−45.7 to 4.9]	−0.58	0.172	1.000

†Odds ratio for women relative to men, Woolf interval; Haldane–Anscombe correction (0.5 added to each cell) where a cell was zero. Risk difference = female minus male proportion. ‡Significant after Holm correction across the 11 contrasts. OR, odds ratio.

Women were more often not employed (14/16, 87.5%) than men (8/15, 53.3%), a difference of 34.2 percentage points (95% CI 4.2-–64.2; OR 6.13, 95% CI 1.02-–36.89; p=0.054). Women more often used a double-lumen catheter (9/16, 56.3%) than men (4/15, 26.7%; OR 3.54, 95% CI 0.78-–16.03; risk difference 29.6 percentage points, 95% CI −3.5 to 62.6; Cohen's h=0.61; p=0.149). A larger share of women had started hemodialysis within the past year (31.3% vs 13.3%; OR 2.95, 95% CI 0.48-–18.34; p=0.394), had hemoglobin of 10 g/dL or less (68.8% vs 53.3%; OR 1.93, 95% CI 0.44-–8.33; p=0.473) and had hypertensive nephrosclerosis recorded as etiology (68.8% vs 46.7%; OR 2.51, 95% CI 0.58-–10.88; p=0.285), whereas chronic pyelonephritis was recorded more often in men (26.7% vs 6.3%; OR 0.18, 95% CI 0.02-−1.88; p=0.172). None of these differences reached statistical significance. The overall distributions of age (p=0.157; V=0.47), hemodialysis vintage (p=0.430; V=0.25), etiology (p=0.158; V=0.50), vascular access (p=0.149; V=0.30) and hemoglobin category (p=0.588; V=0.22) did not differ significantly by sex.

3.4 Comparison with reference populations

The benchmark comparisons are presented in Table 3, with Holm-adjusted p values. The sex distribution (48.4% men) was compatible with the Indonesian Renal Registry (55.5%; p=0.472) and with the proportion of women among incident dialysis patients in Korea (40.5%; p=0.272). The proportion with hypertensive nephrosclerosis (58.1%) was compatible with hypertensive kidney disease in the Indonesian Renal Registry (43.7%; p=0.146; h=0.29), but was five times the 11.5% attributed to hypertension after systematic documentation of primary kidney disease in Jakarta (p<0.001; Holm-adjusted p<0.001; h=1.04). Diabetic nephropathy (12.9%) was less than half the Jakarta proportion of 27.2%, although this difference was not statistically significant (p=0.104; h=−0.36).

Table 3. Comparison of key characteristics with published reference populations.

Characteristic	This study, n/N (%) [95% CI]	Reference, %	Reference population	Exact binomial p	Holm p	Cohen's h
Male sex	15/31 (48.4) [32.0–65.2]	55.5	Indonesian Renal Registry[6]	0.472	1.000	−0.14
Female sex	16/31 (51.6) [34.8–68.0]	40.5	Korean national incident dialysis[12]	0.272	1.000	0.22
Hypertensive etiology	18/31 (58.1) [40.8–73.6]	43.7	Indonesian Renal Registry[6]	0.146	1.000	0.29
Hypertensive etiology	18/31 (58.1) [40.8–73.6]	11.5	Five tertiary centres, Jakarta[23]	<0.001	<0.001‡	1.04
Diabetic nephropathy	4/31 (12.9) [5.1–28.9]	27.2	Five tertiary centres, Jakarta[23]	0.104	0.830	−0.36
Arteriovenous fistula	18/31 (58.1) [40.8–73.6]	84.7	China DOPPS7[26]	<0.001	0.004‡	−0.61
Arteriovenous fistula	18/31 (58.1) [40.8–73.6]	90.7	Japanese national registry[9]	<0.001	<0.001‡	−0.79
Arteriovenous fistula	18/31 (58.1) [40.8–73.6]	35.0	National referral hospital, Tanzania[27]	0.013	0.141	0.47
Employed	9/31 (29.0) [16.1–46.6]	33.3	Working-age patients, Beijing[18]	0.706	1.000	−0.09
Employed	9/31 (29.0) [16.1–46.6]	25.8	Patients aged 19–65 years, 37 European countries[17]	0.683	1.000	0.07
Married	31/31 (100.0) [89.0–100.0]	90.0	Two hemodialysis centres, Riau[25]	0.069	0.618	0.64
Senior high school education	10/31 (32.3) [18.6–49.9]	43.3	Two hemodialysis centres, Riau[25]	0.277	1.000	−0.23
HBsAg-positive	0/31 (0.0) [0.0–11.0]	3.8	Hemodialysis centre, Saudi Arabia[28]	0.631	1.000	−0.39
HBsAg-positive	0/31 (0.0) [0.0–11.0]	11.7	Maintenance hemodialysis, Multan, Pakistan[29]	0.044	0.444	−0.70
HBsAg-positive	0/31 (0.0) [0.0–11.0]	17.6	China DOPPS5[30]	0.004	0.046‡	−0.87

Two-sided exact one-sample binomial test with the published proportion treated as fixed; ‡significant after Holm correction across the 15 comparisons. Reference populations differ in design (incident vs prevalent, age restriction, tertiary case mix). Cohen's h: 0.2 small, 0.5 medium, 0.8 large; positive values indicate a higher proportion in this study. DOPPS, Dialysis Outcomes and Practice Patterns Study; HBsAg, hepatitis B surface antigen.

Arteriovenous fistula use (58.1%) was substantially lower than in Chinese DOPPS7 centres (84.7%; Holm-adjusted p=0.004; h=−0.61) and in the Japanese national registry (90.7%; Holm-adjusted p<0.001; h=−0.79). It was higher than in a Tanzanian national referral hospital (35.0%; p=0.013; h=0.47), but this difference did not remain significant after Holm correction (adjusted p=0.141). Employment (29.0%) was similar to that of working-age hemodialysis patients in Beijing (33.3%; p=0.706) and of dialysis patients aged 19-–65 years across 37 European countries (25.8%; p=0.683). The proportion married (100%) was not significantly different from that in Riau (90.0%; p=0.069), nor was the proportion with senior high school education (32.3% vs 43.3%; p=0.277). The absence of HBsAg-positive patients was compatible with the 3.8% prevalence reported in Saudi Arabia (p=0.631) and, after Holm correction, with the 11.7% reported in Multan, Pakistan (p=0.044; adjusted p=0.444); it remained significantly lower than the 17.6% reported in Chinese DOPPS5 centres (p=0.004; adjusted p=0.046). After correction, four departures were robust: hypertensive

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etiology relative to Jakarta, fistula use relative to China and Japan, and HBsAg positivity relative to China.

3.5 Bivariate and multivariable associations between clinical and sociodemographic characteristics

The attainable odds ratios for the 11 bivariate pairs are shown in Figure 1, with full results in Supplementary Table S1. For every pair, the attainable range included 1.0. The OR for catheter use ranged from 0.057 to 42.69 for vintage <1 year, 0.015-–44.00 for age ≤50 years, 0.015-–7.88 for an etiology other than hypertensive nephrosclerosis and 0.119-–17.53 for diabetic nephropathy. The OR for hemoglobin ≤10 g/dL ranged from 0.089 to 51.92 with respect to catheter use and 0.019-–15.00 with respect to vintage <1 year; the OR for non-employment ranged from 0.346 to 39.27 with respect to no or elementary education and 0.037-–27.20 with respect to age above 50 years. A p value below 0.05 occurred in 0.5% to 5.2% of consistent datasets for the binary pairs and in 3.2% to 8.5% for the ordinal trend tests. None of these bivariate associations is therefore identifiable from the observed counts.

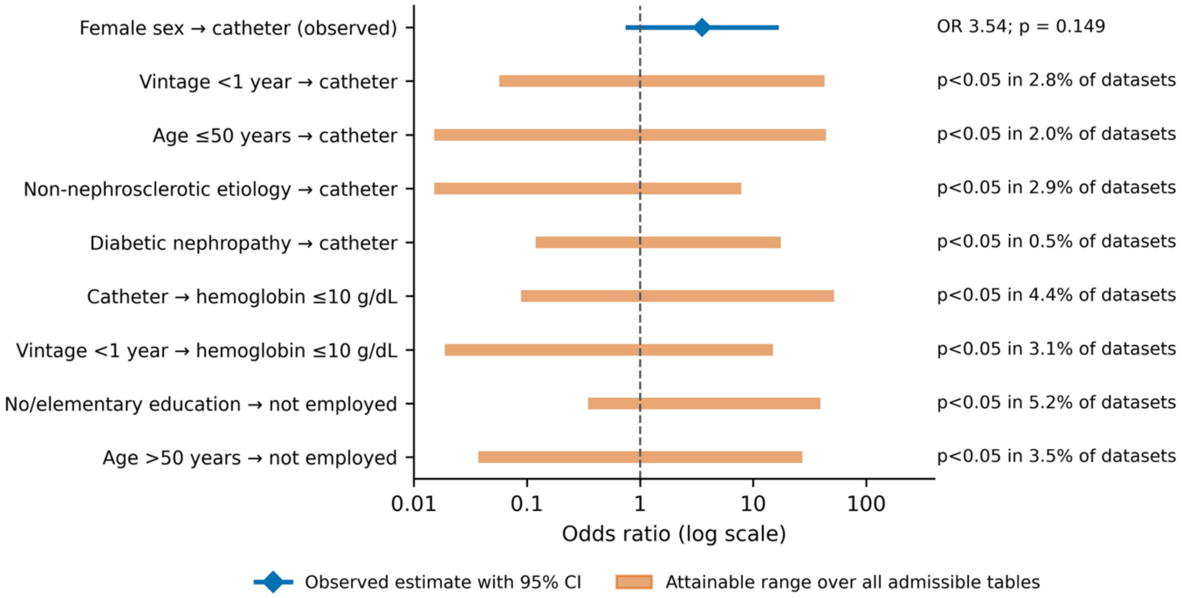

Figure 1. Observed and attainable odds ratios for associations with catheter use, hemoglobin and employment. Blue: observed odds ratio (95% CI) for catheter use in women versus men. Orange: range of odds ratios attainable across all datasets consistent with the observed sex-specific counts; labels give the percentage of those datasets with Fisher p<0.05. Every range crosses 1 (dashed line).

The multivariable models are summarized in Table 4. For catheter use, the median adjusted OR was 3.14 (2.21-–6.50) for female sex, 0.94 (0.14-–6.13) for vintage <1 year, 1.05 (0.22-–4.71) for age ≤50 years and 1.01 (0.18-–5.84) for an etiology other than hypertensive nephrosclerosis, with significance in 1.2% to 2.5% of datasets. For hemoglobin ≤10 g/dL, the median adjusted OR was 1.81 (1.00-–4.13) for female sex, 0.93 (0.21-–5.15) for catheter use, 0.97 (0.15-–9.80) for vintage <1 year and 1.04 (0.22-–4.77) for a non-hypertensive etiology, with significance in at most 2.5% of datasets. For non-employment, female sex had a median adjusted OR of 4.68 (2.74-–14.16) and reached significance in 13.1% of datasets, whereas age >50 years (1.12; 0.14-–5.35) and no or elementary education (1.16; 0.16-–6.26) reached significance in 1.6% and 0.9%. Every attainable range included 1.0, so no predictor was significant in all consistent datasets; under within-sex independence, female sex was the only predictor whose percentile band lay above 1.0 in the catheter and non-employment models.

Table 4. Multivariable Firth-penalized logistic regression across datasets consistent with the observed sex-specific counts.

Predictor	Median adjusted OR [2.5th–97.5th percentile]*	Attainable adjusted OR range†	Datasets with p<0.05, %
Outcome: catheter use (13 events)			
Female sex	3.14 [2.21–6.50]	0.091 to >1000	1.4
Hemodialysis vintage <1 year	0.94 [0.14–6.13]	<0.001 to >1000	1.2
Age ≤50 years	1.05 [0.22–4.71]	<0.001 to >1000	2.0
Etiology other than hypertensive nephrosclerosis	1.01 [0.18–5.84]	<0.001 to >1000	2.5
Outcome: hemoglobin ≤10 g/dL (19 events)			
Female sex	1.81 [1.00–4.13]	0.011 to >1000	0.0
Catheter use	0.93 [0.21–5.15]	<0.001 to >1000	2.1
Hemodialysis vintage <1 year	0.97 [0.15–9.80]	<0.001 to >1000	1.0
Etiology other than hypertensive nephrosclerosis	1.04 [0.22–4.77]	<0.001 to >1000	2.5
Outcome: not employed (22 events)			
Female sex	4.68 [2.74–14.16]	0.16 to 602.57	13.1
Age >50 years	1.12 [0.14–5.35]	0.001 to >1000	1.6
No or elementary education	1.16 [0.16–6.26]	0.001 to >1000	0.9

*Distribution across 5,000 patient-level datasets generated by permuting each variable within sex. †Minimum and maximum adjusted OR located by hill-climbing across consistent datasets. OR, odds ratio.

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4. Discussion

To our knowledge, based on searches of PubMed, this study provides the first description of patients receiving maintenance hemodialysis on a small Indonesian island. At Gema Santi Nusa Penida Regional General Hospital, most of the 31 patients were aged 51-–70 years, evenly divided by sex, all married and mostly not employed. Hypertensive nephrosclerosis was recorded as the cause of kidney failure in close to three in five patients, two in five were dialyzed through a catheter, three in five had hemoglobin of 10 g/dL or less, and none carried hepatitis B surface antigen. Three features distinguish the cohort from national and regional reference populations: fistula use well below that of East Asian dialysis systems, a recorded etiology profile dominated by hypertension with no unknown causes, and a large educational disadvantage among women that persisted after correction for multiple testing. Only employment, marital status and HBsAg status had a category exceeding half of the cohort. In bivariate and multivariable analyses, no association among vascular access, hemoglobin, vintage, age, etiology, education and employment was significant across all consistent datasets, and female sex showed the most consistent association with non-employment and catheter use.

The balanced sex distribution contrasts with the male predominance that characterizes dialysis populations almost everywhere. Women account for 35% of incident kidney replacement patients in Europe and 41% in the United States[11], their share of incident dialysis in Korea fell from 42.8% to 38.2% over two decades[12], men outnumbered women by 1.51 to 1 among Australians starting kidney replacement therapy[13], and men made up 70% of patients in an Indian nationwide hemodialysis network and 70.3% in a Karnataka multicentre profile[16,31]. In Indonesia, 55.5% of registry patients are men[6], and insurance claims show men have 17% higher adjusted odds of receiving hemodialysis[19]. Our proportion of women (51.6%) was statistically compatible with these references, so the balanced distribution should not be over-interpreted, particularly because a prevalent cohort over-represents longer survivors; a Riau series of 30 patients also reported 53.3% women[25]. Two mechanisms nevertheless make a genuinely higher share of women plausible in an island unit. First, women generally survive longer on dialysis — hazard ratios of 0.79 in Korea and 0.51 over ten years in Japan[32,33] — so a prevalent, rather than incident, cohort accumulates women. Second, a local unit removes the travel burden that may disproportionately deter women, whose access to hemodialysis in Indonesia is otherwise lower[19]. A French national study found similar age and emergency-start rates in women and men, but acute nephropathy predicted emergency start only in women[34], a reminder that pathways to dialysis differ by sex even where headline proportions do not.

The age structure resembles that of the national registry, whose mean age is 52 years[6], and of Jakarta patients, whose median age at the start of kidney replacement was 48 years[23]; it is considerably younger than Chinese DOPPS7 centres (mean 61 years)[26] or French incident patients (median 71 years)[34]. The absence of any patient older than 70 years is notable in a population in which the Thai registry alone has followed more than 17,000 patients aged 70 years or older on maintenance hemodialysis[35]. Referral patterns, patient choice, earlier death and dialysis elsewhere are possible explanations. The finding that all five patients aged 40 years or younger were women deserves attention. Although not significant after correction, it is consistent with the aetiological pattern: both patients with lupus nephritis were women, and lupus nephritis is overwhelmingly a disease of young women, 83% of whom were female in a Chinese biopsy cohort[36]. In Jakarta, lupus nephritis accounted for 91% of secondary glomerulonephritis among patients on kidney replacement[23], and in Okinawa kidney failure due to lupus carried 2.55-fold higher all-cause and 4.21-fold higher infection-related mortality than kidney failure from other causes[37], whereas in Korean national data hemodialysis patients with lupus survived longer than those with diabetes[38]. Young women with lupus nephritis on an island unit are therefore a small but high-risk group that warrants specific infection-prevention and rheumatology links.

Educational attainment was low overall, and markedly lower among women. Only three in 16 women had completed senior high school or more, against 11 in 15 men, a large effect (Cohen's h −1.16) that was the one sex difference to survive correction for multiple comparisons. This mirrors the Indian nationwide finding that women on hemodialysis were less educated, less often insured and more often dialyzed through temporary catheters[16]. Low education is itself an independent correlate of CKD in Indonesia (OR 1.31)[1], and higher education is associated with employment on kidney replacement therapy across Europe[17]. In a US cohort, by contrast, educational level was not associated with fistula maturation or two-year survival after access creation[39], suggesting that its effect may operate through access to care and health literacy rather than through the procedure. The educational gap observed here is likely to reflect generational and regional differences in schooling for girls rather than an effect of kidney disease, but its practical consequence is the same: educational materials, consent processes and self-management programmes in this unit need to be designed for patients — especially women — with elementary schooling or none.

Seven in ten patients were not employed, a proportion that did not differ from working-age patients in Beijing (33.3% employed) or dialysis patients across 37 European countries (25.8% employed)[17,18]. International variation is wide — employment among hemodialysis patients ranged from 55% in Japan to 20% in the United States in DOPPS[40] — and in Taiwan, starting dialysis at 25-–34 years cost men 11.8 and women 10.5 years of working life[41]. The sex gradient in our cohort (87.5% of women vs 53.3% of men not employed) matches the Beijing finding that female sex was the strongest independent correlate of non-employment (OR 0.17 for employment)[18]. In the multivariable model, female sex had the strongest association with non-employment (median adjusted OR 4.68), whereas age above 50 years and low education did not, which places sex rather than age or schooling at the centre of employment loss in this cohort. In addition, maintenance hemodialysis requires attendance at two or three sessions each week, which removes a substantial share of available working days from patients and, when a relative accompanies them, from their households.

All patients were married, compared with 90% in Riau[25]. Social support was significantly associated with self-management among Indonesian hemodialysis patients[42]. Universal marriage identifies spouses as a natural target for education about fluid restriction, fistula care and recognition of catheter infection.

The recorded etiology profile warrants careful interpretation. Hypertensive nephrosclerosis (58.1%) was compatible with the 43.7% hypertensive kidney disease recorded in the Indonesian Renal Registry[6], yet it was five times the 11.5% attributed to hypertension in five Jakarta tertiary centres that systematically documented primary kidney disease and classified 31.1% of cases as unknown[23]. No etiology was recorded as unknown in our cohort. Several explanations deserve comparable weight. Attribution practice is one: in patients who present late with small kidneys and hypertension, which is almost universal in kidney failure, hypertensive nephrosclerosis is often recorded by default. A

e-ISSN: 2988-3237
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genuinely different distribution of risk factors on the island is another. Selective survival is a third, because a prevalent cohort retains non-diabetic patients longer. Finally, the Jakarta series drew on tertiary centres and included kidney transplant recipients (24.4%), whose case mix differs from that of a district hemodialysis unit. Hypertension was the main comorbidity in 74.2% of the Jakarta cohort[23], and hypertension and diabetes were the contributors most often cited for CKD hotspots worldwide[4]. Distinguishing primary hypertensive injury from other causes matters prognostically: in the Japanese CKD-JAC cohort, biopsy-proven nephrosclerosis carried a subdistribution hazard ratio of 4.12 for death before kidney replacement compared with IgA nephropathy, and adding biopsy-proven etiology improved eight-year prediction of kidney failure and death[43]. The recorded proportion should therefore be read as the burden of hypertension-attributed kidney failure in clinical records rather than as a validated etiological fraction.

Diabetic nephropathy was recorded in 12.9% of patients, less than half the Jakarta proportion of 27.2%[23], although the difference was not statistically significant. Under-recording is one possibility; survival is another, because diabetic nephropathy is the etiology with the lowest one-year survival in the national registry[6], was associated with a hazard ratio of 1.35 for five-year death[7] and, in Central Java, carried a one-year survival of 86.7% among 1,184 patients[44]. A prevalent cohort sampled over three months will under-represent patients with short survival. The five patients with chronic pyelonephritis (16.1%), four of them men, form a proportion that is rarely reported in dialysis series, where urolithiasis accounted for 10.3% of kidney failure in Jakarta[23]. Obstructive and infective causes are potentially preventable through timely urological care, which is harder to obtain on an island. Environmental and occupational exposures may also contribute in coastal agricultural communities: in rural northeast Thailand, 6.3% of adults had CKD of unknown etiology associated with male sex, uric acid and groundwater contaminated with heavy metals and agrochemicals[45]. The single patient with uric acid nephropathy and the male predominance of chronic pyelonephritis are too few to support inference, but they justify recording exposures and imaging findings in future local data.

Vascular access is the finding with the most direct implications for care. Fistula use of 58.1% was substantially below the 84.7% reported in Chinese DOPPS7 centres[26], the 88.2% in Chinese DOPPS5[30] and the 90.7% in the Japanese registry[9], yet above the 35% of a Tanzanian national hospital cohort[27]. In settings where hemodialysis is initiated late, catheter use at initiation is the norm: 95.5% of Tanzanian patients, 79.9% of Egyptian patients, 72% in Karnataka and 80% of incident Romanian patients started with a catheter[27,31,46,47]. The prognostic consequences are consistent across settings. A meta-analysis of 33 studies found that catheters increase all-cause and infection-related mortality relative to fistulas[48]; tunnelled catheters carried an adjusted hazard ratio of 2.15 for one-year death in Japan[9], catheter use a hazard ratio of 2.18 in Pakistan[10], and catheter initiation a hazard ratio of 2.99 for five-year death in Indonesia[7]. Conversion from catheter to fistula improved survival in Romania (HR 0.27)[47], and pre-dialysis access creation was associated with better maturation and fewer complications in Egypt[46].

The access gap has a local dimension. Temporary access infection affected 39.3% of patients with temporary access at Cipto Mangunkusumo Hospital in Jakarta, with female sex (OR 1.73), low hemoglobin, diabetes and catheter duration (OR 5.32) as risk factors[49], and a West Javanese tertiary centre described ruptured pseudoaneurysm as the leading cannulation complication of fistulas[50]. Managing catheter infection and fistula complications requires surgical or interventional services that an island unit would ordinarily obtain through referral to mainland Bali. Catheter use was higher among women (56.3% vs 26.7%), but the difference was not statistically significant, and its confidence interval ranged from a small reduction to a sixfold increase in odds. Two explanations therefore deserve equal weight. The first is recent initiation: a larger share of women had started hemodialysis within the past year (31.3% vs 13.3%), and among elderly US patients 82.8% remained catheter-dependent three months after fistula creation[51]. The second is consistent with international evidence on sex differences in access: women are less likely to have a fistula attempted within six months (OR 0.64) and to achieve catheter-free fistula use within a year (OR 0.38) in Canada[15], have lower unassisted maturation (26% vs 39%) in the United States[52], and are more likely to be dialyzed through a catheter in a systematic review of 53 studies[14]. In the multivariable model adjusting for vintage, age and etiology, the median adjusted OR for female sex remained 3.14, with a percentile band of 2.21-–6.50 across consistent datasets, but its attainable range included 1, leaving the contribution of recent initiation unresolved.

Three in five patients had hemoglobin of 10 g/dL or less. The comparison with other cohorts is limited by differing thresholds, but the direction is consistent: 18.8% of Chinese DOPPS5 patients had hemoglobin below 9 g/dL[30], only 44.2% of DOPPS7 patients were within 110-–130 g/L[26], anemia prevalence was 89.3% in 22 Liaoning centres[53], hemoglobin was below 10.5 g/dL in 40% of US patient-months[54], and more than half of Palestinian patients were below the KDIGO target, with lower hemoglobin linked to poorer quality of life[55]. The prognostic relationship is U-shaped: in 265,779 Japanese patients, compared with hemoglobin of 10-–10.9 g/dL, the adjusted hazard ratio for death was 1.24 below 9 g/dL and 1.19 at 13 g/dL or above[56]; in US Medicare data the hazard ratio was 2.53 below 9 g/dL[54]; and the association of anemia with mortality in Japan was stronger in non-diabetic patients[57], who form the large majority of this cohort. In Manado, anemia more than doubled the risk of hospitalization within six months (RR 2.32)[58], and hemoglobin below 10 g/dL was one of seven items in a Thai mortality score for the oldest hemodialysis patients[35]. Globally, women account for 55.8% of prevalent CKD-related anemia[59]; a Japanese analysis found no significant sex interaction in the relation of hemoglobin to survival[60], and our data also showed no significant sex difference. Because hemoglobin was recorded as a category without its date, erythropoiesis-stimulating agent dose, iron status or transfusion history, the 61.3% below 10 g/dL identifies an audit target rather than a treatment failure.

No patient was HBsAg-positive. With 31 patients, the 95% CI extends to 11.0%, so the result is compatible with the 2.7-−3.8% prevalence reported from Nagpur and Saudi Arabia[28,61], but significantly lower than the 11.7% from Multan and Uttarakhand and 17.6% from Chinese DOPPS5 centres[29,30,62], and below the pooled African estimate of 9.88%[63]. A zero count should not be read as evidence that hepatitis B is absent from the population or that screening can be relaxed, particularly in a prevalent cohort that may under-represent patients with complications. Protective anti-HBs titres were present in only 66.1% of Saudi patients[28], half of vaccinated Madinah patients were non-protected[64], and only 47.7% of incident Indian patients had completed hepatitis B vaccination before starting dialysis[65]. More importantly for Bali, hepatitis C rather than hepatitis B is the dominant blood-borne threat in hemodialysis. Pooled anti-HCV prevalence is 25.8% among hemodialysis patients in the WHO South-East Asia Region[66], Indonesia has one of the highest pooled prevalences worldwide at 63.6%[67], and 27.8% of patients in two Denpasar units seroconverted after starting dialysis, with vascular access type and dialyzer reuse as the principal risk factors[24]. In Taiwan, treated hepatitis B was more common and liver-related mortality higher among men receiving hemodialysis[68]. Routine anti-HCV and anti-HBs reporting would therefore strengthen infection control in the unit.

These findings have direct implications for kidney services in Klungkung Regency and for island regencies more generally. Indonesian claims data show that the odds of receiving hemodialysis are eight times higher in Java or Bali than in Papua, Maluku and Nusa Tenggara, with the widest gaps in rural areas[19]. Globally, vulnerable groups have unequal access to kidney replacement, and routine kidney testing for older people is offered in only 45% of low-income countries[69]. In the United States most rural counties have no dialysis facility at all[20], and in Brazil the median travel distance to dialysis is three times longer in the North than in the Southeast[21]. Even within the Java–Bali region, which has the greatest access nationally, a hemodialysis unit on an outlying island therefore represents a significant extension of care, and its patient profile provides a template for other islands. Three priorities for audit and evaluation follow, each tied to a specific finding. First, given fistula use well below regional benchmarks, a local vascular access pathway, including planned pre-dialysis fistula creation and a referral arrangement for fistula surgery on mainland Bali, is needed to raise fistula use towards regional benchmarks, with particular attention to women. Second, because three in five patients had hemoglobin of 10 g/dL or less, anemia care should be audited, with hemoglobin, ferritin, transferrin saturation and erythropoiesis-stimulating agent dose recorded at fixed intervals so that under-treatment can be distinguished from treatment resistance. Third, infection surveillance should extend beyond HBsAg to anti-HCV and anti-HBs testing with a documented vaccination programme, in view of the Denpasar seroconversion data[24].

Upstream, the predominance of hypertension-attributed kidney failure and the low educational attainment of patients point to community detection and treatment of hypertension and diabetes as the most direct preventive route. CKD prevalence in Indonesia varies substantially between provinces[2], and CKD with hypertension as its cause is rising fastest worldwide[3]. Health education delivered through primary care on the island must be accessible to adults with elementary schooling or less. Hemodialysis is already the largest cost component of CKD care under national insurance[5]; whether prevention is cost-saving in an island setting, where treatment may also entail transport costs, is a question for formal economic evaluation rather than an inference from these data.

The analysis also defines a concrete research agenda. First, a patient-level registry for the unit, linking all variables for each patient and adding exact age and vintage, first vascular access, catheter type, dialysis frequency and adequacy, hemoglobin with iron indices and erythropoiesis-stimulating agent use, anti-HCV and anti-HBs status, residence and travel time, would allow the associations examined here to be estimated directly. Second, the sex difference in catheter use should be tested prospectively. Because the observed difference is imprecise, the required sample should be planned across a range: about 43 patients per sex would detect a difference of 56% versus 27% with 80% power at α=0.05, 93 per sex a difference of 50% versus 30%, and 162 per sex a difference of 45% versus 30% — samples that require pooling across hemodialysis units in the regency and extended follow-up. Third, a cohort following all incident patients from their first session would record time to fistula creation and maturation, access-related infection and survival, and would avoid the survivorship bias inherent in a prevalent cross-section. Fourth, a validation study comparing recorded etiology with systematic documentation of primary kidney disease, similar to the Jakarta approach[23], would establish whether the hypertension-dominant profile is real. Fifth, hepatitis B surveillance precise enough to exclude a prevalence of 5% would require at least 72 patients with no positive results, which argues for pooling data across units in the regency. Finally, a study of patients from Nusa Penida who are dialyzed on the mainland or who decline dialysis would reveal who does not reach the island unit.

This study has several strengths. It included every eligible patient treated in the hemodialysis unit serving the island, so the cohort is a complete census of the unit's maintenance population during the study window rather than a convenience sample. All proportions are reported with interval estimates, and benchmark comparisons use exact tests against published reference populations, which prevents over-interpretation of "predominant" categories. The sex-stratified counts allowed genuine comparisons between women and men with correction for multiple testing. Finally, bivariate and multivariable associations were examined across every dataset consistent with the observed counts, so the conclusions do not depend on assumptions about how characteristics were linked within individual patients.

This study has limitations. The cohort is small and its intervals are wide. Characteristics were available as sex-specific counts rather than linked patient records, so associations not involving sex were analyzed across consistent datasets rather than estimated directly. Age, vintage and hemoglobin were categorized, and etiology was taken from clinical records. As a prevalent cross-section over three months, the cohort under-represents patients with short survival, such as those with diabetic nephropathy or catheter-related complications. Benchmark comparisons treat published proportions as fixed and involve reference populations that differ in design. Finally, the findings describe a single island unit and may not generalize to other settings.

5. Conclusion

Patients receiving maintenance hemodialysis at Gema Santi Nusa Penida Regional General Hospital were mostly aged 51-–70 years, evenly divided by sex, all married and largely not employed. Fistula use (58.1%, 95% CI 40.8-–73.6) was well below East Asian benchmarks, three in five patients had hemoglobin of 10 g/dL or less, and women had markedly lower educational attainment than men (18.8% vs 73.3% with senior high school education or higher; Holm-adjusted p=0.042), with higher but statistically unconfirmed catheter use. For the unit and for Klungkung Regency, these findings justify auditing vascular access with attention to women, structured anemia and hepatitis C surveillance, and hypertension-focused prevention delivered in formats suited to patients with limited schooling. An incident, patient-level registry pooling hemodialysis units across the regency is required to estimate the links between vascular access, anemia and time on dialysis directly.

Acknowledgements

The authors thank the Director and staff of Gema Santi Nusa Penida Regional General Hospital, particularly the Hemodialysis Unit and the Medical Records Department, for their support in facilitating this study.

Author contributions (CRediT)

G.A.: conceptualization, methodology, data curation, writing – original draft. I.B.W.W.: writing – review and editing. Both authors approved the final version of manuscript.

Ethics approval and consent

This study was approved by the Research Ethics Committee, Faculty of Medicine, Universitas Udayana, Denpasar, Indonesia (No. 2512/UN14.2.2.VII.14/LT/2026; protocol number 2026.03.1.0957). The study used anonymized medical records; individual informed consent was waived in

e-ISSN: 2988-3237
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accordance with institutional protocol. The study was conducted in accordance with the Declaration of Helsinki.

Conflict of interest

The authors declare no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data availability

The aggregated sex-stratified counts analyzed in this study are reported in full in Table 1. Patient-level records are held by Gema Santi Nusa Penida Regional General Hospital and are not publicly available to protect patient confidentiality.

Use of artificial intelligence

The authors declare that no generative artificial intelligence was used in the preparation of this manuscript.

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