University Library

MINERVA ACCESS

A gateway to Melbourne's research publications

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:
Chen, W;Wong, G;Howard, K;Guha, C;van Zwieten, A;Natsky, AN;Mallitt, KA;Khalid, R;Francis, A;Jaure, A;Kim, S;Teixeira-Pinto, A;Bernier-Jean, A;Johnson, DW;Hahn, D;Ryan, EG;McCarthy, HJ;Kiriwandeniya, C;Larkins, N;Caldwell, P;Woodleigh, R;Carter, SA;Kennedy, SE;Alexander, SI;McTaggart, S;Craig, JC;Hawley, CM;Howell, M

Title:
A Within-Trial Economic Evaluation of a Patient Navigator Program in Children With CKD

Date:
2025-09-01

Citation:
Chen, W., Wong, G., Howard, K., Guha, C., van Zwieten, A., Natsky, A. N., Mallitt, K. A., Khalid, R., Francis, A., Jaure, A., Kim, S., Teixeira-Pinto, A., Bernier-Jean, A., Johnson, D. W., Hahn, D., Ryan, E. G., McCarthy, H. J., Kiriwandeniya, C., Larkins, N. ,... Howell, M. (2025). A Within-Trial Economic Evaluation of a Patient Navigator Program in Children With CKD. Kidney International Reports, 10 (9), pp.3202-3212. https://doi.org/10.1016/j.ekir.2025.06.043.

Persistent Link:
https://hdl.handle.net/11343/367597

License:
CC BY-NC-ND

KI REPORTS
KIReports.org

A Within-Trial Economic Evaluation of a Patient Navigator Program in Children With CKD

Check for updates

Winnie Chen[1], Germaine Wong[2,3,4], Kirsten Howard[1], Chandana Guha[2,3], Anita van Zwieten[2,3], Andrea N. Natsky[1], Kylie-Ann Mallitt[2,3,5], Rabia Khalid[6,7], Anna Francis[8,9], Allison Jaure[2,3], Siah Kim[2,3], Armando Teixeira-Pinto[2,3], Amelie Bernier-Jean[10], David W. Johnson[11,12,13], Deirdre Hahn[3,14], Elizabeth G. Ryan[15], Hugh J. McCarthy[3,14,16], Charani Kiriwandeniya[11], Nicholas Larkins[17,18], Patrina Caldwell[3,14], Reginald Woodleigh[19], Simon A. Carter[20,21,22], Sean E. Kennedy[16,23], Stephen I. Alexander[3], Steven McTaggart[8,9], Jonathan C. Craig[24], Carmel M. Hawley[11,12,13] and Martin Howell[1]; on behalf of the NAVKIDS[2] Trial Steering Committee[2,25]

[1]Leeder Centre for Health Policy, Economics and Data, Faculty of Medicine and Health, University of Sydney, Sydney, New South Wales, Australia; [2]School of Public Health, University of Sydney, Sydney, New South Wales, Australia; [3]Centre for Kidney Research, Children's Hospital at Westmead, Sydney, New South Wales, Australia; [4]Department of Renal Medicine, Westmead Hospital, Sydney, New South Wales, Australia; [5]Faculty of Medicine and Health, School of Clinical Medicine, University of New South Wales, Sydney, New South Wales, Australia; [6]Children's Hospital Westmead Clinical School, The University of Sydney, Westmead, New South Wales, Australia; [7]Charles Perkins Centre, The University of Sydney, New South Wales, Australia; [8]Queensland Child and Adolescent Renal Service, Queensland Children's Hospital, Queensland, Australia; [9]School of Medicine, University of Queensland, Queensland, Australia; [10]Canada and CIUSSS du Nord-de-l'Île-de-Montréal, University of Montreal, Montreal, Quebec, Canada; [11]Australasian Kidney Trials Network, University of Queensland, Brisbane, Queensland, Australia; [12]Department of Kidney and Transplant Services, Princess Alexandra Hospital, Brisbane, Queensland, Australia; [13]Translational Research Institute, Brisbane, Queensland, Australia; [14]Discipline of Child and Adolescent Health, Faculty of Medicine and Health, University of Sydney, Sydney, New South Wales, Australia; [15]School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia; [16]Department of Nephrology, Sydney Children's Hospitals Network, Sydney, New South Wales, Australia; [17]Department of Nephrology, Perth Children's Hospital, Perth, Western Australia, Australia; [18]School of Medicine, University of Western Australia, Perth, Western Australia, Australia; [19]Prostate and Breast Cancer Foundation (CanCare), Sydney, New South Wales, Australia; [20]Department of Nephrology, The Royal Children's Hospital Melbourne, Melbourne, Victoria, Australia; [21]Department of Paediatrics, University of Melbourne, Melbourne, Victoria, Australia; [22]Prevention Innovation, Murdoch Children's Research Institute, Melbourne, Australia; [23]Faculty of Medicine and Health, School of Clinical Medicine, University of New South Wales, Sydney, New South Wales, Australia; and [24]College of Medicine and Public Health, Flinders University, Adelaide, South Australia, Australia

Introduction: The NAVKIDS[2] trial was a patient navigation program for children and their caregivers living with chronic kidney disease (CKD) in Australia. We conducted a within-trial economic evaluation to describe the cost-effectiveness of patient navigation compared with standard care.

Methods: Cost and resource utilization data were prospectively collected over 6 months, from a health care funder perspective. Costs were reported in Australian dollars. Quality-of-life (QoL) data were collected from 0 to 6 months. Incremental cost-effectiveness ratios (ICERs) were reported as the additional cost/quality-adjusted life years (QALYs) gained.

Results: Over the 6-month period, total per-patient costs were higher in the patient navigation group than in those in the standard care group ($10,249 vs. $9368, respectively; $P < 0.001$). There was no significant difference in mean health care costs between the 2 groups ($9848 vs. $9368, respectively, $P = 0.98$); however, the intervention group incurred an additional cost of $1075/person for the patient navigator. There was no significant difference in total QALYs over 6 months between patient navigation and standard care groups (0.33 vs. 0.30, respectively; $P = 0.11$). The ICER for the intervention group compared with usual care was $41,960/QALY gained with a wide 95% confidence interval (CI) (−$300,123 to +$769,958), indicating substantial uncertainty.

Correspondence: Winnie Chen, Leeder Centre for Health Policy, Economics and Data Level 5, Moore College, 1 King Street, Newtown New South Wales 2042, Australia. E-mail: winnie.chen@sydney.edu.au

[25]Members of the NAVKIDS[2] Trial Steering Committee are listed in the Appendix

Received 13 May 2025; accepted 23 June 2025; published online 2 July 2025

Conclusion: The economic evaluation found that the cost of patient navigators is relatively low compared with total health care costs; however, there is considerable uncertainty regarding the cost-effectiveness of the intervention. Further research is needed to evaluate long-term cost-effectiveness as well as potential impacts on health outcomes and health care utilization.

Kidney Int Rep (2025) **10,** 3202–3212; https://doi.org/10.1016/j.ekir.2025.06.043
KEYWORDS: chronic kidney disease; cost; cost-effectiveness; economic evaluation; patient navigation; pediatric nephrology
© 2025 International Society of Nephrology. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

CKD in children is associated with congenital anomalies, hereditary conditions, neurocognitive conditions, and other complex morbidities.[1,2] Beyond medical needs, CKD impacts children and their families in terms of carer burden, psychological wellbeing, and social function.[3,4] Ensuring optimal access to high-quality, multidisciplinary support is essential for improving health outcomes and overall QoL in this vulnerable population.[5] However, access to such services differs considerably across geographical locations, socioeconomic, and ethnic groups.[6,7] These inequities are further compounded by policy constraints, high out-of-pocket expenses, the financial burden of managing a lifelong chronic illness, and limited support resources.[7–9] The health inequities observed among children with CKD from socioeconomically disadvantaged backgrounds are key drivers of poorer health and QoL. Our previous research indicated that children from lower socioeconomic backgrounds experience poorer overall self-rated and proxy-rated health and significantly diminished QoL compared with their more affluent peers.[10,11]

To address these challenges, multifaceted interventions such as patient navigator programs have been proposed. In the recently published randomized controlled trial, we evaluated the effectiveness of NAVKIDS^2,[12] a patient navigator program for children with CKD living in rural or remote Australia, and from low socioeconomic backgrounds. In the NAVKIDS^2 trial, patient navigators assisted families and caregivers to navigate the complex health care system, improve care coordination, and facilitate access to necessary resources and services.[13] Although findings from the NAVKIDS^2 trial did not show a significant improvement in the overall health and QoL for patients and caregivers, or lead to a reduction in the number of hospitalizations and missed school days compared with standard care, the qualitative findings reported some positive benefits. Caregivers reported that during times of uncertainty and stress, patient navigation provided valuable support in care coordination, guidance, and assistance with navigating complex health care systems. Patient navigation also fostered the development of self-care skills and enhanced self-advocacy, empowering caregivers to take a more active role in managing their child's care. These findings underscore the potential importance of patient navigation as a source of support and comfort for families and caregivers, even though the quantitative measures of health outcomes remained unchanged within this short timeframe.[14,15]

In addition to qualitative and quantitative outcomes, economic evidence is essential for evaluating the value-for-money of programs such as NAVKIDS^2 and informing future clinical practice. Economic evaluations compare the costs and health outcomes of a health program or intervention, compared with a comparator (e.g., usual care).[16,17] Cost-effectiveness is frequently reported in terms of additional cost of the program per QALYs gained. Whether a program is considered cost-effective depends on whether the cost per QALY gained exceeds a willingness-to-pay threshold. The willingness-to-pay threshold varies across different countries and is dependent on the clinical context.

To date, few economic evaluations have been conducted on patient navigator programs, and none have been conducted among children with CKD.[13] In this study, we aimed to quantify the costs of the NAVKIDS^2 trial, assess the cost-effectiveness of patient navigation among children with CKD compared with standard care, and identify the key factors influencing overall health care utilization and costs. Findings from this economic evaluation will provide the necessary evidence to enable informed and efficient health care resource allocation.

METHODS

Overview and Setting

A within-trial economic evaluation was conducted, using a health care funder perspective (Australian federal and state governments). Australia has a universal health care scheme in which the federal government through Medicare funds public hospital services, reimburses health care services via an itemized Medicare Benefits Scheme (MBS) (e.g., investigations, primary care, and specialist visits), and

subsidizes the cost of medications via the Pharmaceutical Benefits Scheme (PBS).[18] Full details of the NAVKIDS[2] trial methods and main trial findings have been previously published.[12,19,20] In brief, the trial was conducted between 2019 and 2022 at 5 pediatric nephrology units located across Australia in Sydney, Brisbane, Perth, and Melbourne. Within the trial, 162 participants were randomized into 2 groups, namely the "immediate" group ($n = 80$), who received the patient navigator intervention immediately following enrolment; and the "waitlist" group ($n = 82$), who received usual care for 6 months before receiving the intervention. For all participants, individual patient-level data were prospectively collected, including demographics, medical history, and patient navigator usage logs. This was linked with health care utilization and cost data, which included hospital, MBS, and PBS datasets.

The evaluation followed the Consolidated Health Economic Evaluation Reporting Standards (CHEERS 2022) checklist to ensure transparent reporting (Supplementary Material).[21] A 6-month time horizon was used, covering the period in which those randomized to the immediate group received the patient navigator intervention, whereas participants in the waitlist group received standard care. Costs were reported in Australian dollars (AUD) for 2022. No discounting was applied to costs or outcomes given the short duration of the trial. Data analysis was performed using R version 4.2.3[22] and STATA 17.0.[23] Ethics approval was obtained from the Sydney Children's Health Network Human Research Ethics Committee (HREC/18/SCHN/325). Written informed consent was obtained from the parents or caregivers of the participants.

Costs

Health care costs were obtained from linked datasets, including hospital datasets for inpatient costs using Australian Refined Diagnosis Related Groups[24] and emergency department costs using urgency disposition groups[25]; MBS dataset for the costs of investigations, primary care, and specialist visits[26]; and PBS dataset for costs of medications.[27]

Costs of patient navigators were calculated using trial-based salaries, with an estimated hourly rate of $47.25/h. This was based on 2021 costs for employing a patient navigator, 0.4 full-time equivalent across 5 hospital sites, including 30% on-costs, for a duration of 6 months for the intervention group only. An additional analysis using patient navigator logs, the number of hours spent, and therefore the cost of direct patient-facing activities (travel, contact with patients, organizing patient follow-up) was conducted (Supplementary Table S1). This showed that direct patient activities accounted for approximately a quarter of all patient navigator salary costs. The NAVKIDS[2] trial was conducted during the COVID-19 pandemic, where many patient navigators worked from home and conducted their interactions via telehealth. Potential additional expenses in a nonpandemic setting, such as office space, access to information technologies, and travel costs for in-person interactions with patients and their families in outpatient and inpatient settings, were not included in intervention cost estimates.

Cost Analysis and Cost-Effectiveness Analysis

A cost analysis was conducted, comparing differences in average costs/person between the immediate and waitlist groups over a 6-month period. Bootstrapping, a widely used nonparametric method in economic evaluations, was used to draw 10,000 random sample datasets with replacement, to recalculate the incremental costs for each bootstrapped sample. Bootstrapped samples were generated within each treatment group separately, preserving the original group sizes. The percentage of draws with cost savings was calculated to assess the robustness of the cost difference estimate. In terms of missing data, a small number of patients did not consent for data linkage to MBS and PBS datasets (9 patients, with 3 in the immediate group, 6 in the waitlist group). In the main cost analysis, we included individuals with complete cost data only. In the sensitivity analysis, we included all randomized patients and conservatively assumed costs to be 0, where hospital, MBS, or PBS costs were unavailable.

Effectiveness outcomes reported in the NAVKIDS[2] trial included self-rated health (SRH) and QoL of the child using Health Utilities Index Mark 3 over 6 months.[12,19] In the trial, these outcomes were recorded at 0 (baseline), 1, 3, and 6 months (Supplementary Tables S2 and S3). For the cost-effectiveness analysis, we compared differences in the immediate and waitlist groups in terms of proportion (%) of patients with improved SRH scores from 0 to 6 months, and proportion of patients with the same or improved SRH scores from 0 to 6 months between groups. We also calculated QALYs using Health Utilities Index Mark 3 outcomes for multiattribute utility; and reported differences between groups in terms of time-weighted total QALYs over the 6-month period (0 to 6 months). Bootstrapping with 1000 samples was used to estimate a 95% CI around the ICER. The ICER was calculated as the ratio of the incremental cost difference between the immediate and waitlist groups to the incremental gains in total QALYs observed between these 2 groups. For the cost-effectiveness analysis, we included the cost

Table 1. Health care utilization and costs/person from 0 to 6 months – immediate group versus waitlist group

Category	All (N = 153)	Immediate group (n = 77)	Waitlist group (n = 76)	Difference (immediate − waitlist)	P-value
Health care utilization (n/person)					
Hospital	2 (9)	2 (9)	2 (9)	0	0.70
MBS	10 (19)	6 (13)	13 (24)	−7	0.03
PBS	4 (8)	2 (5)	5 (10)	−3	0.01
Health care costs ($/person)					
Hospital	$8407 (20,425)	$8870 (20,814)	$7937 (20,151)	+$933	0.70
MBS	$461 (982)	$347 (845)	$576 (1097)	−$229	0.06
PBS	$742 (2123)	$631 (2238)	$854 (2008)	−$223	0.02
Total healthcare	$9609 (20,850)	$9848 (20,862)	$9368 (20,974)	+$480	0.98
Intervention costs ($/person)					
Patient navigator	N/A	$1075	$0	+$1075	N/A
Total costs ($/person)					
Total	N/A	$10,923 (20,862)	$9368 (20,974)	+ $1555	< 0.001

MBS, Medicare Benefits Scheme; PBS, Pharmaceutical Benefits Scheme.
Continuous variables expressed as mean (SD). P-values calculated using Wilcoxon rank sum test. Costs are in AUD 2022. Counts and dollars rounded to whole numbers. P-values rounded to 2 decimal places.

data used for the cost analysis with missing outcome data imputed using the mean value for the relevant treatment arm.

Statistical Analysis

Power calculations were performed based on the trial primary outcome.[12,19] Descriptive statistics for health care utilization and costs were reported across the whole cohort (n = 162), and by randomization group. Continuous variables were presented as means with SD, and categorical variables were summarized using frequencies and percentages. Generalized linear models (GLMs) with fixed effects were used to identify factors associated with higher health care costs in children with CKD, considering key demographic factors such as age, sex, dialysis and transplant status, and self-reported comorbidities. Uncommon conditions, defined as comorbidities present in ≤ 5 individuals within the cohort, were excluded to improve stability of the models. Eight candidate GLMs were initially considered. These included 4 one-part models with 2 distributions (Gaussian and Gamma) and 2 link functions (identity and log); and 4 two-part models using the "twopartm" R package,[28] where the first part modeled the probability of non-0 observations using logistic regression, and the second part modeled costs for positive observations using GLMs with the same specifications as the 1-part models. Due to data sparseness, several models failed to converge and were subsequently excluded from the model selection. The most appropriate model was selected based on predictive accuracy and model parsimony.

RESULTS

The NAVKIDS[2] trial included 162 study participants, with 80 children in the immediate group and 82 children in the waitlist group. Complete cost data were available for 77 individuals in the immediate group, and 76 individuals in the waitlist group (Supplementary Figure S1).

Health Care Costs and Utilization Comparison Between Groups

Over the 6-month period, total costs were higher in the patient navigation group compared with those in the standard care group ($10,249 vs. $9368 respectively; $P < 0.001$) (Table 1). There was no significant difference in mean health care costs between these 2 groups (Figure 1, $9848 vs. $9368, respectively; $P = 0.98$); however, the intervention group incurred an additional cost of $1075/person related to staffing patient navigators. The immediate group had comparable

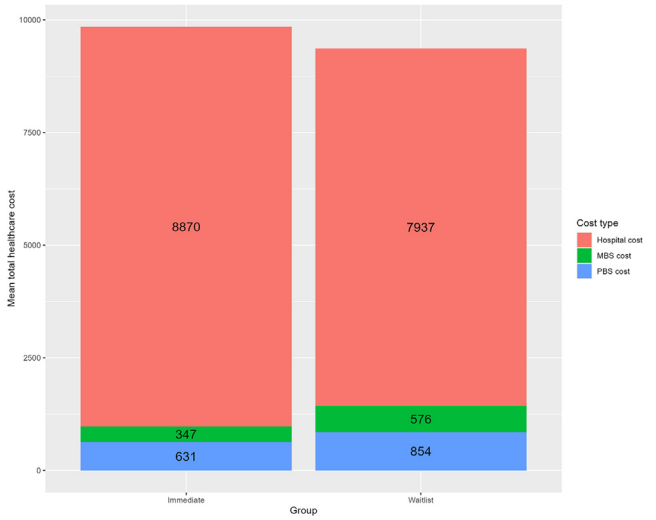

Figure 1. Mean healthcare costs/person from 0 to 6 months – immediate group versus waitlist group. MBS, Medicare Benefits Scheme; PBS, Pharmaceutical Benefits Scheme.

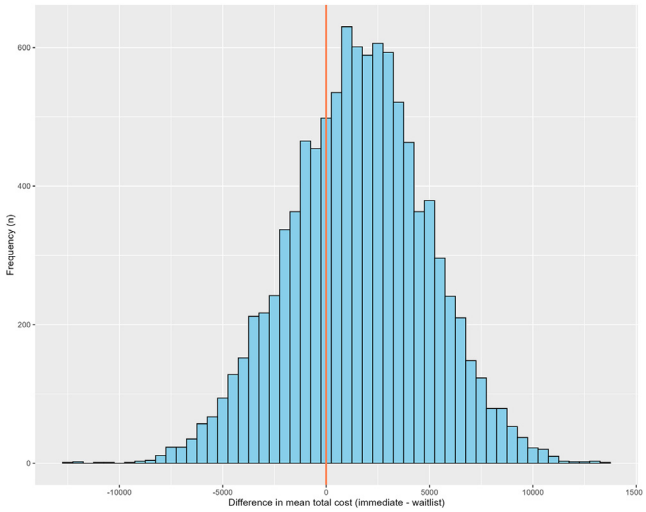

Figure 2. Difference in mean total costs/person from 0 to 6 months – immediate group versus waitlist group. Bootstrapped results of differences in mean total costs between immediate and waitlist groups, 10,000 iterations. Orange line indications where there is zero difference in costs between groups. MBS, Medicare Benefits Scheme; PBS, Pharmaceutical Benefits Scheme.

health care utilization to the waitlist group in terms of the mean number of hospitalizations. However, the immediate group had lower health care utilization of MBS and PBS items compared with the waitlist group.

The mean differences in total costs over 6 months between the 2 groups, using 10,000 bootstrapped samples, is shown in Figure 2. Approximately 68% of the bootstrapped samples resulted in higher costs within the immediate group compared with the waitlist group. Sensitivity analysis results are shown in Supplementary Table S4. When all trial participants were included and 0 costs were assumed for missing cost data, health care costs across all categories (total, hospital, MBS, and PBS) were marginally reduced in both the immediate and waitlist groups compared with the main analysis, where only complete cases were used.

Patterns in Health Care Utilization and Costs for Children With CKD

For the entire cohort of children with CKD included in the trial, total health care costs were $9609/person over the 6-month period, with hospital emergency department and inpatient costs contributing to the majority (87%) of total health care costs. In Table 1 and Supplementary Tables S5 to S10, we show the common and high-cost items for hospitalizations, MBS, and PBS for the entire cohort. Hemodialysis attendance was the most common reason for hospitalization, followed by admissions related to "other kidney and urinary tract disorders and infections." The highest cost diagnosis-related group items over the 6-month period were transplantation expenses, followed by the costs of treating other kidney and urinary tract disorders and infections, and hemodialysis. Common MBS items included pathology items (blood tests and urine tests) and attendances for general practice or physician consultations. These MBS items also contributed the most to MBS costs. Common PBS items included prednisolone, antibiotics, and immunosuppression use (such as tacrolimus and mycophenolate mofetil). PBS items that contributed the most to PBS costing included somatropin, tacrolimus, and whey protein formula supplementation (which is PBS-indicated for children with CKD).

Factors Associated With Increased Health Care Costs

For the cohort of children with CKD included in the trial, associations between patient characteristics and increased health care costs were analyzed. Among the multivariable models considered, the GLM with a Gaussian distribution and an identity link was selected as the most appropriate model (Supplementary Table S11). Univariable regression model results are available in Supplementary Table S12. The final multivariable GLM regression model (Table 2) included demographic factors and clinical comorbidities, including CKD status, and presence of comorbidities. The patient navigator intervention was not associated with a difference in total health care costs. Dialysis had the strongest association with increased health care costs. On average, a child on dialysis had an additional $33,556/6 months in terms of health care costs, compared with those with CKD alone ($P < 0.001$). Having hematological conditions was associated with higher health care costs (+$22,214/6 mo; $P < 0.01$), compared with children with CKD but without hematological conditions. Ethnicity was also associated with a difference in health care costs in the multivariable model ($P = 0.03$).

Cost-Effectiveness Analysis Results

In Table 3, we show the incremental change in costs and all outcomes, and ICER results for the immediate group versus waitlist group. In terms of total QALYs over the 6-month period, the immediate group had similar results compared with the waitlist group (0.33 vs. 0.30, respectively; $P = 0.11$). No significant differences were observed in the changes in QALYs from baseline to 6 months or in the percentage improvement in SRH over the 6-month period. The ICERs for the immediate compared with the waitlist group were $41,960 (95% CI: −$300,123 to +$769,958) per QALY, $54,087 (95% CI: −$436,200 to +$398,900) per child improving in SRH from baseline and $13,670

Table 2. Factors associated with increased health care costs, multivariable model

Characteristic	Additional cost/person, per 6 mo ($)	95% CI	*P*-value
Waitlist group (vs. immediate)	−3834	−10,178 to 2510	0.24
Age category, yr			0.81
• 0–5	—	—	
• 5–10	−3715	−12,364 to 4934	
• 10–15	−4058	−12,893 to 4777	
• ≥ 15	−3737	−16,304 to 8830	
Male (vs. female)	−1856	−8401 to 4690	0.58
Low income	615	−6087 to 7317	0.86
Ethnicity			0.03
• First Nations Australians	—	—	
• European Australians	11,353	−1406 to 24,111	
• Other	16,183	3483 to 28,883	
Rurality			0.21
• MMM 1 to 2 (metropolitan and regional)	—	—	
• MMM 3 to 5 (rural)	6002	−1554 to 13,558	
• MMM 6 to 7 (remote and very remote)	−2897	−15,052 to 9258	
CKD status			< 0.001
• CKD	—	—	
• Dialysis	33,556	18,523 to 48,589	
• Transplant	−1219	−9249 to 6812	
Hypertension	5724	−2538 to 13,985	0.18
Bone disease	2031	−11,377 to 15,440	0.16
Growth deficiency	6510	−2652 to 15,672	0.84
Chronic infection	−402	−11,109 to 10,305	0.94
Behavioral	8511	−8828 to 25,850	0.34
Endocrine	2863	−9723 to 15,450	0.66
Gastrointestinal	−4098	−14,914 to 6717	0.46
Other	3420	−3984 to 10,824	0.37
Hematology	22,214	4413 to 40,016	0.01
Neurology	−3386	−10,936 to 4163	0.38
Respiratory	9734	−1,329 to 20,797	0.09
Cardiovascular	−1670	−12,795 to 9454	0.77
Hearing	4965	−7630 to 17,561	0.44
Urological	−1691	−15,126 to 11,743	0.81

CI, confidence interval; CKD, chronic kidney disease; GLM, Generalized linear model; MMM, Modified Monash Model (category).
Multivariable regression results of GLM with a Gaussian distribution and an identity link. Model diagnostics available in Supplementary Table S9. Costs are in AUD 2022. Counts and dollars rounded to whole numbers. *P*-values rounded to 2 decimal places.

(95% CI: −$260,008 to +$253,121) per child with SRH remaining the same or improving. The 95% CI values indicate a very high degree of uncertainty in these estimates. The ICER scatterplots of bootstrapped results for the cost-effectiveness outcomes are visually displayed in Figure 3.

Table 3. Incremental cost-effectiveness ratio results

Group	Total cost ($)	Total QALYs (0 to 6 mo)	% SRH improved (0–6 mo)	% SRH same or improved (0–6 mo)
Immediate ($n = 47$)	$10,923	0.332	46.8 %	59.4%
Waitlist ($n = 47$)	$9368	0.295	44%	48%
Difference[a]	$1555	0.037	2.8%	11.4%
P-value	0.64	0.07	0.76	0.23
ICER ($ per incremental outcome difference)	N/A	$41,960	$54,087	$13,670
ICER 95% CI[b] (lower, upper)	N/A	−300,123 to 769,958	−436,200 to 398,900	−260,008 to 253,121

CI, confidence interval; ICER, incremental cost-effectiveness ratio; QALYs, quality-adjusted life years; SRH, self-rated health.
[a]Differences in all costs and outcomes were not statistically significant ($P > 0.05$).
[b]Bootstrapped results using 1000 iterations.
Included all patients with cost data for the cost analysis with missing outcomes imputed using averages for the group. Dollars rounded to whole numbers. *P* values rounded to 2 decimal places. Other numbers rounded to 3 decimal places.

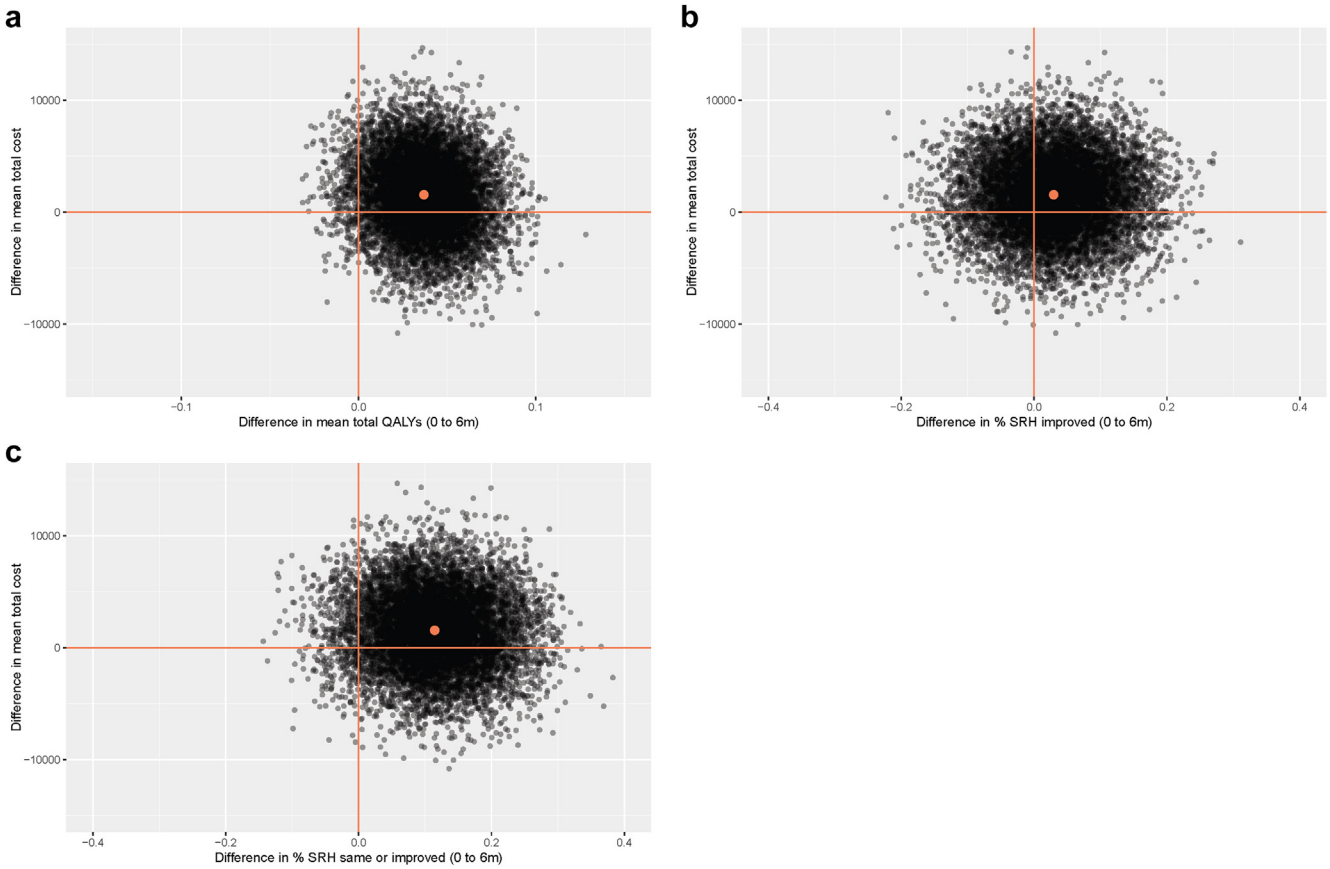

Figure 3. Bootstrapped results – incremental cost-effectiveness scatterplots (immediate – waitlist). Figures 3a to c show bootstrapped results for ICERs, 1000 iterations, immediate minus waitlist group. (a) Costs per total QALY (0–6 months), (b) cost per % SRH improved (0–6 months), (c) cost per % SRH same or improved (0–6 months). ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life years; SRH, self-rated health.

DISCUSSION

This economic evaluation found that the cost of patient navigators is relatively low compared with total health care costs; however, there is considerable uncertainty regarding the cost-effectiveness of the intervention. Over a 6-month period, the overall health care cost for children with CKD was an average of $9609/person, with little difference between immediate and waitlist groups. The costs of patient navigation were, on average, $1075/person. The overall ICER showed a very high degree of uncertainty per QALY gained. Such observed variability was primarily driven by variations in resource use across different patient groups, settings (rural vs. urban), and underlying comorbid conditions and the very small difference in QALYs over the 6 months. Key factors associated with the overall increased health care costs were dialysis and treatments for hematological malignancies.

A recent systematic review of randomized controlled trials of patient navigation programs for children with chronic disease reported that only 4 studies had assessed costs or cost-effectiveness associated with these programs.[13] All 4 studies reported that patient navigation reduced costs and/or improved QALYs compared with standard care. Three of the included studies were among children with asthma, and demonstrated reductions in cost and/or health care utilization with the use of patient navigators.[29-31] One study examined the cost-effectiveness of a patient navigator intervention for children with chronic noncomplex medical conditions (e.g., attention-deficit/hyperactivity disorder) in Australia; this study found a modest but nonstatistically significant reduction in health service costs and an ICER of $548/QALY.[32] Consistent with previous studies, our study reported uncertainty around the cost-effectiveness of the patient navigation intervention. Direct comparisons of economic evaluation results between patient navigation studies are limited because of heterogeneity in the medical conditions included, variations in both patient navigator programs and health care settings, trial duration, and other differences in evaluation methodologies.[13]

This study contributes to a better understanding of health care costs and resource utilization of children

with CKD in a setting with universal health care coverage. In contrast to our study, which examined health care costs and resource utilization across the whole health care setting, most costing studies in children with CKD to-date have been conducted in the US and primarily assessed the costs of inpatient hospitalizations.[33,34] As expected, dialysis was associated with significantly higher health care costs and resource utilization in children with CKD, consistent with findings reported in adults receiving dialysis.[35] Children treated with dialysis experience multicomorbidities, including cardiovascular disease, hypertension, neurological disorders, growth and cognitive impairment, and other syndromic disorders.[36,37] These comorbidities contributed to the complexity of care, and the need for comprehensive and multidisciplinary approaches to improve care and outcomes in this vulnerable and disadvantaged population. Hematological disorders and malignancy were associated with higher costs and resource utilization. Children who experienced these conditions often required specialized treatments such as chemotherapy and radiation therapy, frequent hospitalizations, and ongoing monitoring, further amplifying the financial and resource burden on health care systems.

Understanding the total resources use and the predictors of costs is essential for the successful implementation of patient navigator programs in clinical settings. Identifying the key cost drivers, such as dialysis costs and expenses related to the management of comorbidities, enables policymakers and administrators to accurately map costs and expenses, and budget effectively during the scaling-up planning phase, while maintaining program sustainability. Intervention fidelity is also crucial, because variation in children's conditions across different CKD stages, living in rural versus urban areas, different ethnicities and cultural backgrounds, and difference between jurisdictions may influence the program delivery and outcomes, and ultimately affect the total costs. For example, maintaining optimal intervention fidelity may require initial and ongoing training for the patient navigators, adding to upfront and recurrent costs. Additional monitoring, audits, and feedback mechanisms to ensure fidelity may increase total administrative and personnel costs in real-life situations. Other investments such as standardized tools and technologies may also be necessary to support consistent intervention delivery. However, these costs would be offset in the longer term through improved outcomes and resource efficiency and economies of scale in both training and resource development, ensuring the program remains cost-effective and sustainable.

In our study, the costs, resource use, and QoL data were prospectively collected and directly linked to the MBS and PBS datasets, alongside routinely collected hospital administrative data from all participating sites. The strength of this approach is that it enabled comprehensive analysis across the health sector, including specialist outpatient visits, general practice consultations, diagnostic investigations, medications, attending emergency departments, and admitted care. The use of MBS and PBS data and administrative records mitigated the risk of recall bias, providing an objective and robust assessment of the total health care costs. In addition, our study included a diverse cohort of children, including those from lower socioeconomic backgrounds, and residing in rural and remote settings, thereby ensuring the cost estimates are not only representative of the Australian health care context, but were also applicable to experiences of children experiencing socioeconomic disadvantage or rurality in other high income countries with universal health care funding systems.

Our study had several limitations. First, there were missing baseline and follow-up outcome data, including a relatively high proportion of SRH and Health Utilities Index Mark 3 scores. A small number of individuals also had missing data related to resource use, because not all children and their caregivers consented to linkage with the MBS and PBS. Second, although the adoption of the 6-month time horizon was consistent with the trial follow-up period, it is plausible that sustained implementation of the program over a longer time frame would potentially generate long-term benefits and costs. Benefits may include improved access to timely and appropriate services, better health outcomes, and reduced reliance on acute care, all of which would have costs associated with them. Consequently, the longer-term resource use, costs, and health outcomes may differ from those observed in the trial period. Future modelled analyses may consider estimating the longer-term cost-effectiveness of the navigation intervention because this has the potential to inform policy decisions regarding broader adoption and sustainable funding of the intervention. Third, the use of a health care funder perspective did not capture societal costs (e.g., productivity losses in caring for a child with CKD). The inclusion of productivity costs may further improve and strengthen the cost-effectiveness of the patient navigator intervention. In addition, we did not include caregiver out-of-pocket costs such as travel costs, or other additional costs related to specialist visits, which would lead to an underestimation of the total costs incurred in both arms of the trial. Understanding the broader societal impact of patient navigation, including the out-of-pocket costs and the caregiver burden will be critical for informing the sustainability and real-world implementation of the program.

In conclusion, we have shown that the patient navigation program is a relatively inexpensive intervention within the trial. However, there are uncertainties related to the overall costs and benefits because the short-term QoL gains associated with the intervention remain nonsignificant between the immediate and waitlist groups. Whereas the short-term costs of implementing the patient navigation program are modest, longer-term evaluations are needed to capture the full spectrum of the costs and benefits, including the societal and caregivers' perspectives, to further establish the sustainability and cost-effectiveness of patient navigation interventions in children with CKD.

APPENDIX

List of members of the NAVKIDS[2] Trial Steering Committee

Germaine Wong (Cochair), Centre for Kidney Research at The Children's Hospital at Westmead and Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia; Carmel Hawley (Co-Chair), Princess Alexandra Hospital, the Translational Research Institute and Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Allison Jaure, Sydney School of Public Health, The University of Sydney; Amanda Walker, Department of Nephrology, Royal Children's Hospital, Melbourne, Australia; Amelie Bernier-Jean, University of Montreal, Canada; Anita van Zwieten, Centre for Kidney Research at The Children's Hospital at Westmead and Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia; Anna Francis, Children's Health Queensland Hospital and Health Service, Brisbane, Australia; Armando Teixeira-Pinto, Centre for Kidney Research at The Children's Hospital at Westmead and Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia; Alistair Mallard, Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Chandana Guha, Centre for Kidney Research at The Children's Hospital at Westmead and Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney Australia; Charani Kiriwandeniya, Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; David Johnson, Princess Alexandra Hospital, the Translational Research Institute and Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Deirdre Hahn, Centre for Kidney Research at The Children's Hospital at Westmead, Sydney, Australia; Donna Reidlinger, Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Elaine Pascoe, Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Elizabeth Ryan, QCIF Facility for Advanced Bioinformatics and Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Fiona Mackie, Department of Renal Medicine, Sydney Children's Hospital, Randwick, Sydney, Australia; Hugh J McCarthy, Centre for Kidney Research at The Children's Hospital at Westmead; Jonathan Craig, College of Medicine and Public Health, Flinders University, Adelaide, Australia; Julie Varghese, Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Kirsten Howard, Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia; Liza Vergara, Australasian Kidney Trials Network, The University of Queensland, Brisbane, Australia; Luke Macauley, The University of Sydney, Sydney, Australia; Martin Howell, Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia; Michelle Irving, The University of Sydney, Sydney Australia; Nicholas Larkins, Perth Children's Hospital, Perth, Australia; Patrina Caldwell, Centre for Kidney Research at The Children's Hospital at Westmead and Discipline of Child and Adolescent Health, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia; Rabia Khalid, Centre for Kidney Research at The Children's Hospital at Westmead, Sydney, Australia; Reg Woodleigh, Prostate and Breast Cancer Foundation (CanCare), Sydney, Australia; Sean Kennedy, Department of Renal Medicine, Sydney Children's Hospital, Randwick, Sydney, Australia; Shilpanjali Jesudason, Department of Renal Medicine, Royal Adelaide Hospital, Adelaide, Australia; Simon Carter, Department of Nephrology, Royal Children's Hospital, Melbourne, Australia; Stephen Alexander, Centre for Kidney Research at The Children's Hospital at Westmead, Sydney, Australia; and Steve McTaggart, Children's Health Queensland Hospital and Health Service and The University of Queensland, Australia.

DISCLOSURE

DWJ has received consultancy fees, research grants, speaker's honoraria, and travel sponsorships from Baxter Healthcare and Fresenius Medical Care; consultancy fees from AstraZeneca, Bayer, and AWAK; speaker's honoraria from ONO and Boehringer Ingelheim & Lilly; and travel sponsorships from Ono and Amgen. All the other authors declared no competing interests.

ACKNOWLEDGMENTS

We would like to acknowledge all our patient navigators and participants for their contributions to the study. REDCap UQ: Study data were collected and managed using REDCap electronic data capture tools hosted at the

University of Queensland. REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing the following: (i) an intuitive interface for validated data capture, (ii) audit trails for tracking data manipulation and export procedures, (iii) automated export procedures for seamless data downloads to common statistical packages, and (iv) procedures for data integration and interoperability with external sources.

Funding

This trial was supported by the National Health and Medical Research Council fund under the category: Medical Research Future Fund Targeted Call for Research: Rare Cancers, Rare Diseases and Unmet Need Initiative (APP1170021). The funders had no role in the design and conduct of the study; data collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

DATA AVAILABILITY STATEMENT

The data collected for the study, including individual patient data and a data dictionary that defines each field in the data set, will be made available as deidentified participant data to researchers who propose to use the data for individual patient data meta-analysis. Data will be shared following approval of the proposal by the corresponding author and a signed data access agreement, beginning 2 years following main publication.

AUTHOR CONTRIBUTIONS

WC, GW, KH, and MH conceived the study. WC conducted data analysis and drafted the initial manuscript. WC, GW, KH, CG, AvZ, AN, and MH contributed to the study design, methodological approach, and interpretation of results. All the authors critically revised the manuscript for intellectual content and approved the final manuscript.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Figure S1. Flowchart of included participants.

Table S1. Patient navigator costs 0 to 6 months for immediate group – direct patient interactions.

Table S2. Baseline and follow-up SRH.

Table S3. Baseline and follow-up QALYs.

Table S4. Sensitivity analysis of health care utilization and costs/person from 0 to 6 months – immediate group versus waitlist group.

Table S5. Most common diagnosis-related group codes over 6 months period, overall trial cohort (immediate and waitlist groups).

Table S6. Highest cost diagnosis-related group codes over 6 months period, overall trial cohort (immediate and waitlist groups).

Table S7. Most common MBS items over 6 months period, overall trial cohort (immediate and waitlist groups).

Table S8. Highest cost MBS items over 6 months period, overall trial cohort (immediate and waitlist groups).

Table S9. Most common PBS items over 6 months period, overall trial cohort (immediate and waitlist groups).

Table S10. Highest cost PBS items over 6 months period, overall trial cohort (immediate and waitlist groups).

Table S11. Comparison of cost association models and model diagnostics.

Table S12. Factors associated with increased health care costs, univariable models.

Consolidated Health Economic Evaluation Reporting Standards (CHEERS 2022) checklist.

REFERENCES

1. Becherucci F, Roperto RM, Materassi M, Romagnani P. Chronic kidney disease in children. *Clin Kidney J*. 2016;9:583–591. https://doi.org/10.1093/ckj/sfw047
2. Hooper SR, Johnson RJ, Gerson AC, et al. Overview of the findings and advances in the neurocognitive and psychosocial functioning of mild to moderate pediatric CKD: perspectives from the Chronic Kidney Disease in Children (CKiD) cohort study. *Pediatr Nephrol*. 2022;37:765–775. https://doi.org/10.1007/s00467-021-05158-w
3. Wee LX, Tan PST, Chen HC. Experiences and needs of families caring for children and adolescents with chronic kidney disease: a meta-synthesis. *J Pediatr Nurs*. 2022;63:52–63. https://doi.org/10.1016/j.pedn.2021.12.028
4. Tong A, Lowe A, Sainsbury P, Craig JC. Parental perspectives on caring for a child with chronic kidney disease: an in-depth interview study. *Child Care Health Dev*. 2010;36:549–557. https://doi.org/10.1111/j.1365-2214.2010.01067.x
5. VanSickle JS, Warady BA. Chronic kidney disease in children. *Pediatr Clin North Am*. 2022;69:1239–1254. https://doi.org/10.1016/j.pcl.2022.07.010
6. van Zwieten A, Kim S, Dominello A, Guha C, Craig JC, Wong G. Socioeconomic position and health among children and adolescents with CKD across the life-course. *Kidney Int Rep*. 2024;9:1167–1182. https://doi.org/10.1016/j.ekir.2024.01.042
7. Guha C, Khalid R, Mallitt K-A, et al. Perspectives of caregivers on access to health care for children with CKD. *Kidney Int Rep*. 2024;9:3177–3189. https://doi.org/10.1016/j.ekir.2024.08.029
8. Medway M, Tong A, Craig JC, et al. Parental perspectives on the financial impact of caring for a child with CKD. *Am J Kidney Dis*. 2015;65:384–393. https://doi.org/10.1053/j.ajkd.2014.07.019
9. Tong A, Henning P, Wong G, et al. Experiences and perspectives of adolescents and young adults with advanced CKD. *Am J Kidney Dis*. 2013;61:375–384. https://doi.org/10.1053/j.ajkd.2012.09.024
10. Shingde R, Guha C, van Zwieten A, et al. Longitudinal associations between socioeconomic position and overall health

of children with chronic kidney disease and their carers. *Pediatr Nephrol*. 2024;39:1533–1542. https://doi.org/10.1007/s00467-023-06236-x

11. Didsbury M, van Zwieten A, Chen K, et al. The association between socioeconomic disadvantage and parent-rated health in children and adolescents with chronic kidney disease-the Kids with CKD (KCAD) study. *Pediatr Nephrol*. 2019;34:1237–1245. https://doi.org/10.1007/s00467-019-04209-7
12. Wong G, Guha C, Mallitt KA, et al. The randomized controlled trial (NAVKIDS(2)) of a patient navigator program created for children with chronic kidney disease. *Kidney Int*. 2024;106:736–748. https://doi.org/10.1016/j.kint.2024.05.031
13. Lalji R, Koh L, Francis A, et al. Patient navigator programmes for children and adolescents with chronic diseases. *Cochrane Database Syst Rev*. 2024;10:Cd014688. https://doi.org/10.1002/14651858.CD014688.pub2
14. McBrien KA, Ivers N, Barnieh L, et al. Patient navigators for people with chronic disease: a systematic review. *PLoS One*. 2018;13:e0191980. https://doi.org/10.1371/journal.pone.0191980
15. Willard-Grace R, Tuot DS. NAVKIDS^2: a lesson in matching outcome measures to interventions. *Kidney Int*. 2024;106:568–570. https://doi.org/10.1016/j.kint.2024.07.018
16. Chen W, Howell M, Cass A, Gorham G, Howard K. Understanding modelled economic evaluations: a reader's guide for clinicians. *Med J Aust*. 2024;221:302–307. https://doi.org/10.5694/mja2.52409
17. Wong G, Howard K, Craig JC. Economic evaluation in clinical nephrology: Part 1. An introduction to conducting an economic evaluation in clinical practice. *Nephrology (Carlton)*. 2010;15:434–440. https://doi.org/10.1111/j.1440-1797.2010.01294.x
18. Department of Health and Aged Care. The Australian Health System Australia. Commonwealth of Australia. 2024. Accessed December 1, 2024. https://www.health.gov.au/about-us/the-australian-health-system
19. van Zwieten A, Caldwell P, Howard K, et al. NAV-KIDS2 trial: protocol for a multi-centre, staggered randomised controlled trial of a patient navigator intervention in children with chronic kidney disease. *BMC Nephrol*. 2019;20:134. https://doi.org/10.1186/s12882-019-1325-y
20. van Zwieten A, Ryan EG, Caldwell P, et al. NAVKIDS2 trial: a multi-centre, waitlisted randomised controlled trial of a patient navigator intervention in children with chronic kidney disease — statistical analysis plan and update to the protocol. *Trials*. 2022;23:824. https://doi.org/10.1186/s13063-022-06783-y
21. Husereau D, Drummond M, Augustovski F, et al. Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) statement: updated reporting guidance for health economic evaluations. *BMC Med*. 2022;20:23. https://doi.org/10.1186/s12916-021-02204-0
22. R Core Team. R: A Language and Environment for Statistical Computing Vienna, Austria. R Foundation for Statistical Computing. 2024. Accessed December 1, 2024. https://www.R-project.org/
23. StataCorp. *Stata Statistical Software: Release 17*. College Station, TX: StataCorp LLC; 2025.
24. Independent health and aged care pricing authority. AR-DRGs Australia: IHACPA. 2024. Accessed December 1, 2024. https://www.ihacpa.gov.au/health-care/classification/admitted-acute-care/ar-drgs
25. Independent health and aged care pricing authority. Urgency Disposition Groups Australia: IHACPA. 2024. Accessed December 1, 2024. https://www.ihacpa.gov.au/health-care/classification/emergency-care/udg
26. Department of Health and Aged Care. MBS Online - Medicare Benefits Schedule Australia: Commonwealth of Australia. 2024. Accessed December 1, 2024. https://www.mbsonline.gov.au/
27. Department of Health and Aged Care, PBS. The pharmaceutical benefits scheme Australia: Commonwealth of Australia. 2024. Accessed December 1, 2024. https://www.pbs.gov.au/pbs/home
28. Duan Y, Emir B, Bell G, Cabrera J. twopartm: two-Part Model with Marginal Effects: R package version 0.1.0. 2022. Accessed April 1, 2025. https://CRAN.R-project.org/package=twopartm
29. Martin MA, Pugach O, Mosnaim G, et al. Community health worker asthma interventions for children: results from a clinically integrated randomized comparative effectiveness trial (2016–2019). *Am J Public Health*. 2021;111:1328–1337. https://doi.org/10.2105/AJPH.2021.306272
30. Karnick P, Margellos-Anast H, Seals G, Whitman S, Aljadeff G, Johnson D. The pediatric asthma intervention: a comprehensive cost-effective approach to asthma management in a disadvantaged inner-city community. *J Asthma*. 2007;44:39–44. https://doi.org/10.1080/02770900601125391
31. Flores G, Bridon C, Torres S, et al. Improving asthma outcomes in minority children: a randomized, controlled trial of parent mentors. *Pediatrics*. 2009;124:1522–1532. https://doi.org/10.1542/peds.2009-0230
32. Carter HE, Waugh J, Chang AB, et al. Cost-effectiveness of care coordination for children with chronic noncomplex medical conditions: results from a multicenter randomized clinical trial. *Value Health*. 2022;25:1837–1845. https://doi.org/10.1016/j.jval.2022.06.008
33. Taliwal N, Pandya A, Dixon A, et al. Economic burden of inpatient hospitalizations for pediatric chronic kidney disease in the US. *Pediatr Nephrol*. 2024;40:1059–1068. https://doi.org/10.1007/s00467-024-06568-2
34. Modi ZJ, Waldo A, Selewski DT, Troost JP, Gipson DS. Inpatient pediatric CKD health care utilization and mortality in the United States. *Am J Kidney Dis*. 2021;77:500–508. https://doi.org/10.1053/j.ajkd.2020.07.024
35. Pockros BM, Finch DJ, Weiner DE. Dialysis and total health care costs in the United States and worldwide: the financial impact of a single-payer dominant system in the US. *J Am Soc Nephrol*. 2021;32:2137–2139. https://doi.org/10.1681/ASN.2021010082
36. Wong CJ, Moxey-Mims M, Jerry-Fluker J, Warady BA, Furth SL, CKiD. CKiD (CKD in children) prospective cohort study: a review of current findings. *Am J Kidney Dis*. 2012;60:1002–1011. https://doi.org/10.1053/j.ajkd.2012.07.018
37. Francis A, Didsbury MS, van Zwieten A, et al. Quality of life of children and adolescents with chronic kidney disease: a cross-sectional study. *Arch Dis Child*. 2019;104:134–140. https://doi.org/10.1136/archdischild-2018-314934