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Continuity of care: evaluating a multidisciplinary care model for people with early CKD via a nationwide population-based longitudinal study

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ABSTRACT

Objectives To control and prevent the burdens associated with chronic kidney disease (CKD), Taiwan's National Health Insurance Administration (NHIA) launched the 'early-CKD programme' in 2011 to extend care and education to patients with CKD. This study aims to evaluate the effectiveness of the early-CKD programme in terms of continuity of care (COC).

Design and participants This study used secondary data from 2010 to 2014 provided by the NHIA to identify 86 581 participants each for the intervention and control groups. Patients with CKD who participated in the early-CKD programme between 2011 and 2013 were defined as the intervention group. For the control group, propensity score matching was used to select patients with CKD who did not participate in the programme, but were seen by the same group of physicians.

Intervention A multidisciplinary care model for patients with early CKD launched in 2011.

Primary outcome measures Outcome variables included the continuity of care index (COCI), which measures a physician's COC; number of essential examinations; and resource utilisation. To better identify the difference between groups, we separated COCI into two groups based on mean: high (above mean) and low (below mean). A generalised estimating equation model was used to examine the effects of the early-CKD programme.

Results The programme significantly increased the number of essential examinations/tests administered to patients (β=0.61, p<0.001) and improved COCI between physicians and patients (OR=4.18, p<0.001). Medical expenses (β=1.03, p<0.001) and medication expenses (β=0.23, p<0.001) significantly increased after the programme was implemented, but patients' kidney-related hospitalisations and emergency department visits decreased (β=−0.13, p<0.001).

Conclusion From the COC viewpoint, the programme in Taiwan showed a positive effect on COCI, number of essential examinations and resource utilisation.

Strengths and limitations of this study

- The population-based data set provides a higher level of accuracy than a smaller data set can provide.
- This is only an initial examination of continuity of care for an early-CKD programme in Taiwan.
- The use of claims data rather than clinical data might obscure the true efficacy of the programme.

BACKGROUND

In most developed countries, 10%–13% of the general population have chronic kidney disease (CKD). Although only 0.03%–0.23% have end-stage renal disease (ESRD) and have received renal replacement therapy, 2%–7% of the annual healthcare budget, or 30–100 times the average individual's healthcare expenditure, is used for this population.[1–3] Most ESRD cases develop from progressive CKD, which is becoming a tremendous economic burden. CKD is also associated with high premature mortality and disability rates[4] and an 8-fold to 10-fold increase in cardiovascular mortality.[5 6] CKD is also a risk multiplier in patients with diabetes and hypertension. CKD is a neglected non-communicable disease and is becoming a global public health issue.[7]

Some countries have started prevention programmes to address this burden.[3 8 9] Multidisciplinary care (MDC) models that incorporate professionals from various aspects of the healthcare system have been widely adopted.[10–13] Some have even provided financial incentives (pay-for-performance (P4P)) to healthcare providers who participate in such programmes.[14] Studies have shown that these programmes are effective in containing medical expenditures for predialysis patients, reducing hospitalisation and better controlling CKD complications.[15–17] However, incidence and mortality rates were hardly improved,[18–21] likely because it was too late to start prevention at early-CKD stages.

In 2003, Taiwan's National Health Insurance Administration (NHIA) proposed multidisciplinary educational and care

projects targeting patients with pre-ESRD, and in 2006, it launched a programme to promote early and active CKD intervention. The projects encourage medical institutions to build multidisciplinary renal teams led by nephrologists that include nurses, dieticians, case managers and pharmacists to set up professional CKD training courses and health management system platforms, in addition to review systems for the platforms. They also screened high-risk groups, starting from the relatives of dialysis patients, and established screening tools in local communities. The programmes primarily aimed to slow the progression of CKD and reduce ESRD incidence.[22] In 2018, 191 medical institutions provided kidney health promotion services.[23]

To increase patients' knowledge of kidney disease and improve healthcare management, the project was expanded to a nationwide pre-ESRD P4P programme moderated by the NHIA. Initial reports have shown that the programme may be decreasing dialysis and mortality rates, and is saving on CKD-related costs.[15 16 24 25] Nevertheless, the incidence of ESRD has remained unchanged.

To help address Taiwan's rapidly ageing population and other increasingly common risk factors, the NHIA in 2011 launched a programme for patients with early CKD (stages 1–3a) in high-risk populations, such as the elderly or those with diabetes mellitus, hypertension or a family history of CKD. The programme was designed to achieve three main goals: to provide patient-centred care, to ensure follow-up care is provided by the same physicians, and to pay providers according to a P4P scheme.[26] Physicians other than nephrologists, cardiologists and endocrinologists joined the care model to encourage patients with early CKD to enroll in the programme. The ultimate aim is to enhance the efficiency and effectiveness of disease management through medical care and further education. However, there were some issues with the programme that need to be highlighted: (1) patients with early CKD are relatively young and healthy, so they are more reluctant to change their diet and behaviours, and (2) patients usually visit primary and general healthcare providers, so general practitioners (GPs) should be able to provide kidney care. For the first issue, the MDC model could help by providing wider and deeper contact with patients. As part of the P4P programme that rapidly expanded nationwide, GPs and other professionals are asked to take a 6-hour kidney care training course and retain at least 20% of new enrollees each year. They are also subject to periodic reviews. The 6-hour training course for GPs and other professionals covers basic care protocol for patients with CKD, including the definition and stages of CKD, medicinal regimens, care protocol for patients with comorbidities and healthy lifestyle.[26] Education for patients with CKD is required to include an introduction to the disease (symptoms and how to interpret test results), instructions on maintaining a healthy lifestyle, and administering medication, diet, the importance of returning for follow-ups and how to slow the progress of CKD.[26]

Continuity of care (COC) is a core element of primary care and has been linked to adherence.[27 28] For patients with chronic diseases, a long-term physician–patient relationship can improve communication and enhance understanding, leading to effective chronic disease management.[29–31] COC is also helpful for health providers to understand patients' medication adherence and retention of disease knowledge.[32 33] The continuity of care index (COCI) has been used to evaluate the effectiveness of prevention programmes for diseases such as diabetes mellitus, hypertension and chronic obstructive pulmonary disease, but not yet for CKD.[34–36] As it takes a long time for early CKD to develop into ESRD, it is difficult to evaluate the effectiveness of an early-CKD prevention programme based solely on the incidence of ESRD. Therefore, this study aims to understand the association between COCI and resource utilisation before and after an early-CKD programme intervention.

METHODS

Data sources

This study used NHIA claims data from 2010 to 2014 of patients with CKD who enrolled in an early-CKD intervention programme. Enrollees were identified by their payment code: P4301C, P4302C and P4303C.[37] All personal identification was removed, and the authors accessed the data under strict supervision of the NHIA. To be included in the study, patients with CKD had to be >20 years old and should have made at least three outpatient visits or been admitted to hospitals more than once for CKD-related diseases. Patients who had received dialysis or a kidney transplant were excluded. The International Classification of Diseases, Ninth Revision, Clinical Modification of CKD was defined by the US Renal Data System and the NHIA of the Taiwanese Ministry of Health and Welfare, including 016.0, 095.4, 189.0, 189.9, 223.0, 236.91, 250.4, 271.4, 274.1, 283.11, 403.x1, 404.x2, 404.x3, 440.1, 442.1, 447.3, 572.4, 581–588, 591, 642.1, 646.2, 753.12–753.19, 753.2 or 794.4.[38 39]

Study subjects

This study used an intervention and a control group. The intervention group included eligible subjects who participated in the early-CKD programme any time from 2011 to 2013. Their claims data were collected the year before the index year and 1 year after the index year. The study excluded subjects who participated in the pre-ESRD programme before they enrolled in the early-CKD programme. The index date was defined as the first day an eligible patient enrolled in the early-CKD programme between 1 January 2011 and 31 December, 2013. The timeline is plotted in figure 1.

The control group included patients with CKD cared for by the physicians who joined the care model, but who did not enrol in the early-CKD programme during the study period. Propensity score matching was used to match subjects in both groups in terms of gender, age, year of

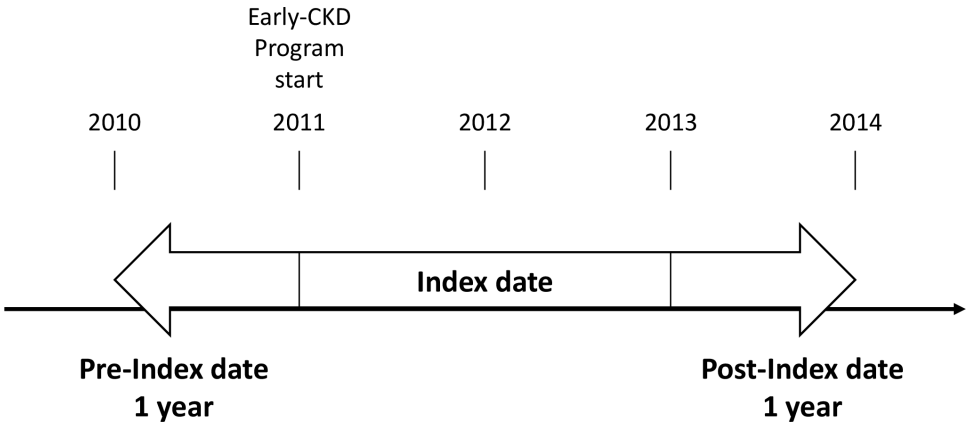

Figure 1 Participant study period. CKD, chronic kidney disease.

diagnosis, comorbidity (such as hypertension, diabetes and cardiovascular diseases), Dartmouth-Manitoba's Charlson Comorbidity Index (D-M's CCI),[40] accreditation level and location of hospitals that participants visited most frequently. Each group had 86 581 eligible participants to assure matched distribution (figure 2).

Study variables

Outcome variables

Five outcome variables were included: COCI, number of essential examinations/tests and resource utilisation (number of admissions to hospitals or emergency department (ED) visits due to kidney-related illness, medical expenditures and medication expenditures). The COCI score measured the physicians' COC from 0 to 1. The higher the score, the better the COC provided to patients, meaning that patients regularly visited the same physicians. The COCI formula is as follows, where N is the total number of outpatient CKD care visits, n_i is the number of outpatient CKD care visits to a physician (i) and M is the total number of physicians[32]:

$$\frac{\sum_{i=1}^{M} n_i^2 - N}{N(N-1)}$$

To better identify the difference between groups, we used means of COCI to transform COCI into two groups: high (above mean) and low (below mean).

Essential examinations/tests included regular urine protein-to-creatinine ratio or urine albumin-to-creatinine ratio tests during outpatient visits. The number of admissions to hospitals or ED visits due to kidney-related illness, medical expenditures (outpatient and inpatient) and medication expenditures were measured as resource utilisation indicators.

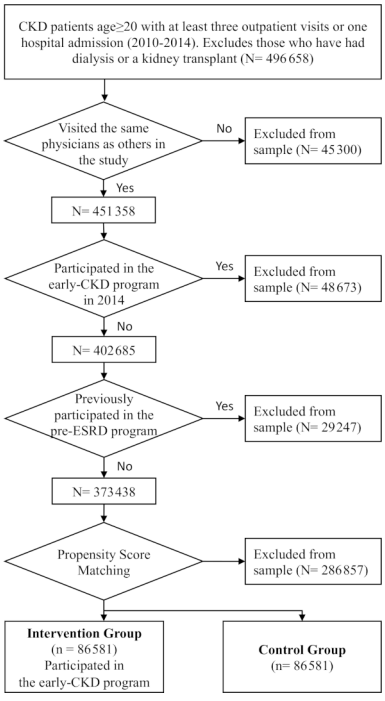

Figure 2 Study participant screening process. CKD, chronic kidney disease; ESRD, end-stage renal disease.

Independent variables and covariates

This study included demographic variables, D-M's CCI index, comorbidity (including diabetes, hypertension and cardiovascular disease), hospital accreditation level (medical centre, regional hospital, district hospital, community clinic and unclear) and hospital location (Taipei area, northern, central, southern, Kaohsiung/Pingtung, eastern and unclear). Interaction terms of the intervention/control group and time were also examined.

The D-M's CCI scores 17 categories of disease, including myocardial infarction; congestive heart failure; peripheral vascular disease; cerebrovascular disease; dementia; chronic pulmonary disease; connective tissue disease; ulcer disease; mild liver disease; diabetes; diabetes with end-organ damage; hemiplegia; moderate or severe renal disease; any tumour, leukaemia, lymphoma; moderate or severe liver disease; metastatic solid tumour; and AIDS on a scale starting from 0 (no=0, mild=1, moderate=2, severe=≥3).[41] For this study, 16 of the categories—excluding moderate or severe renal disease—need to be considered.[42]

Statistical analysis

Data were analysed by SAS V.9.4. Descriptive statistics were reported. Standardised mean difference (SMD) analysis was

Table 1 Characteristics of participants in the prematched and postmatched samples

Group Independents	Prematched sample					Postmatched sample				
	Intervention (n=92 522)		Control (n=280 916)			Intervention (n=86 581)		Control (n=86 581)		
	n	%	n	%	SMD	n	%	n	%	SMD
Gender										
Male	47 401	51.2	153 783	54.7	0.07	44 821	51.8	44 821	51.8	0.00
Female	45 121	48.8	127 133	45.3		41 760	48.2	41 760	48.2	
Age (years)										
≤55	22 421	24.2	85 743	30.5	0.14	21 087	24.4	21 087	24.4	0.00
56–65	28 021	30.3	64 894	23.1	0.16	25 686	29.7	25 686	29.7	0.00
66–75	26 189	28.3	61 503	21.9	0.14	24 222	28.0	24 222	28.0	0.00
76+	15 891	17.2	68 776	24.5	0.17	15 586	18.0	15 586	18.0	0.00
First year in early-CKD programme										
2011	21 542	23.3	71 104	25.3	0.04	19 269	22.3	19 269	22.3	0.00
2012	28 908	31.2	88 203	31.4	0.00	27 561	31.8	27 561	31.8	0.00
2013	42 072	45.5	121 609	43.3	0.04	39 751	45.9	39 751	45.9	0.00
CCI index score										
0	16 836	18.2	96 468	34.3	0.37	16 711	19.3	16 928	19.6	0.00
1–2	46 667	50.4	103 518	36.9	0.27	42 428	49.0	41 919	48.4	0.01
≥3	29 019	31.4	80 930	28.8	0.05	27 442	31.7	27 734	32.0	0.00
Comorbidity										
Diabetes	58 357	63.1	113 852	40.5	0.46	52 642	60.8	52 240	60.3	0.01
Hypertension	64 396	69.6	152 667	54.3	0.32	59 414	68.6	60 219	69.6	0.02
Cardiovascular diseases	25 137	27.2	74 224	26.4	0.01	23 817	27.5	24 062	27.8	0.00
Hospital accreditation level										
Medical centre	14 371	15.5	67 815	24.1	0.21	12 067	13.9	12 067	13.9	0.00
Regional hospital	25 014	27.0	100 071	35.6	0.18	23 778	27.5	23 778	27.5	0.00
District hospital	12 944	14.0	4 473	15.9	0.05	12 507	14.4	12 507	14.4	0.00
Community clinic/unclear	40 193	43.4	68 292	24.3	0.41	38 229	44.2	38 229	44.2	0.00
Hospital location										
Taipei region	3918	4.2	70 485	25.1	0.61	3915	4.5	3915	4.5	0.00
Northern region	5636	6.1	25 972	9.2	0.11	5601	6.5	5601	6.5	0.00
Central region	19 450	21.0	44 338	15.8	0.13	17 101	19.8	17 101	19.8	0.00
Southern region	8600	9.3	33 427	11.9	0.08	7876	9.1	7876	9.1	0.00
Kaohsiung/Pingtung region	14 105	15.2	32 850	11.7	0.10	13 269	15.3	13 269	15.3	0.00
Eastern region	625	0.7	5809	2.1	0.11	593	0.7	593	0.7	0.00
Unclear	40 188	43.4	68 035	24.2	0.41	38 226	44.2	38 226	44.2	0.00

Standardised mean difference (SMD)=difference in mean outcome between groups/SD of outcome among participants; SMD >0.1 means there is a significant difference.
CCI, Charlson Comorbidity Index; CKD, chronic kidney disease.

used to compare outcomes before and after the implementation of the early-CKD programme between the intervention and control groups. Regression, generalised estimating equation (GEE) models, adjusted demographic variables (such as gender, age and comorbidity) and hospital characteristics (such as accreditation level and location) were used to examine the relationship between independent and dependent variables. Moreover, the COCI GEE model was analysed based on binomial distribution and logit link, whereas the models on other outcome variables were based on Poisson distribution.

Patient and public involvement

Patients and the public were not involved in this study.

Table 2 Distribution of dependent variables by period of participation in the early-CKD programme

Period	Pre-early CKD 1 year		Post-early CKD 1 year	
Dependents	Mean	SD	Mean	SD
Number of essential examinations/tests (mean, SD)				
Intervention group	1.12	1.16	2.76	1.42
Control group	0.50	0.96	0.67	1.13
COCI (mean, SD)				
Intervention group	0.24	0.40	0.81	0.28
Control group	0.37	0.44	0.44	0.45
Kidney-related inpatient or ED visits (N, %)				
Intervention group	0.04	0.24	0.04	0.27
Control group	0.12	0.51	0.16	0.63
Medical expenses* (mean, SD)				
Intervention group	4963	20 432	17 491	32 857
Control group	12 540	62 657	15 836	69 253
Medicine expenses* (mean, SD)				
Intervention group	5676	9209	7670	11 488
Control group	5260	10 005	5669	9789

*Measured in payment points, which fluctuate from month to month. A point is equivalent to 0.9 New Taiwanese Dollars, which is equivalent to US$0.03. (Retrieved: https://rate.bot.com.tw/xrt?Lang=zh-TW)
CKD, chronic kidney disese; COCI, continuity of care index; ED, emergency department.

RESULTS

To ensure even distribution after matching, the intervention and control groups were selected based on propensity score (calculated by participants' age, CCI index score, comorbidity, accreditation level and hospital location). Table 1 shows no significant difference between groups in the baseline characteristics of patients between the prematched sample (SMD >0.1) and after matching (SMD <0.1). Further analysis was conducted based on the postmatched samples.

Descriptive statistics of the study variables are shown in table 2. The average number of essential examinations/tests in the intervention group was higher than in the control group in the pre-early CKD programme, which was considered as the baseline year. One year after the early-CKD programme, the average number of essential examinations/tests of the intervention group was higher than in the baseline year. The average COCI for the two groups was similar in the baseline year. One year after the early-CKD programme, the mean COCI for the intervention group increased nearly four times to 0.81, but that of the control group only increased to 0.44 from the baseline year. The number of hospital admissions or ED visits due to kidney-related diseases were similar in the baseline year (0.04) and 1 year after participating in the programme for the intervention group, but increased from 0.12 to 0.16 1 year after the programme for the control group. Healthcare and medication expenditures for the intervention group were higher than for the control group 1 year after the programme. The number of essential examinations and total medicine expenses were higher in the year before intervention for the intervention group, whereas all other outcome variables (COCI, kidney-related inpatient or ED visits, and medical expenses) were higher in the control group. After intervention, all outcome variables were higher in the intervention group.

Further analysis on the effects of the early-CKD programme was confirmed by the GEE models shown in table 3. The number of essential examinations/tests (β=0.61, p<0.001) and medication expenses (β=0.08, p<0.001) increased more for the intervention group between the preintervention year and postintervention year than for the control group. However, hospital admissions (β=−1.18, p<0.001) and healthcare expenses (β=−0.92, p<0.001) decreased significantly for the intervention group. Younger patients (age ≤55 years, OR=1; age >76 years, OR=0.74) were most likely to visit the same physicians.

DISCUSSION

Major findings

An examination of early-CKD intervention programme outcome variables shows that the intervention group had a significantly higher number of renal laboratory examinations, healthcare expenses and medication expenses compared with the control group after matching for propensity scores. The number of emergency services provided and hospitalisations were similar before and after the intervention.

The group-and-time interaction effect, or the OR, of COCI was 4.18, significantly higher in the intervention

Table 3 Effect of early-CKD programme (GEE model)

Dependents / Independents (reference)	Number of essential examinations/tests β	P value	COCI* OR	P value	Kidney-related inpatient or ED visits β	P value	Medical expenses β	P value	Medicine expenses β	P value
Intervention group (control group)	0.81	<0.001	0.57	<0.001	−1.18	<0.001	−0.92	<0.001	0.08	<0.001
Period (pre-early CKD 1 year)										
Post-early CKD 1 year	0.29	<0.001	1.31	<0.001	0.27	<0.001	0.23	<0.001	0.08	<0.001
Interaction group×period	0.61	<0.001	4.18	<0.001	−0.13	<0.001	1.03	<0.001	0.23	<0.001
Gender (female)	0.01	0.531	1.04	<0.001	0.02	0.254	0.08	<0.001	−0.01	0.524
Age (≤55 years)										
56–65	−0.03	<0.001	0.92	<0.001	−0.17	<0.001	−0.12	<0.001	0.07	<0.001
66–75	−0.07	<0.001	0.85	<0.001	−0.09	0.002	−0.15	<0.001	0.11	<0.001
76+	−0.14	<0.001	0.74	<0.001	0.27	<0.001	−0.10	<0.001	0.05	<0.001
Hypertension (none)	0.04	<0.001	1.21	<0.001	0.20	<0.001	0.16	<0.001	0.32	<0.001
Diabetes (none)	0.10	<0.001	0.84	<0.001	−0.29	<0.001	−0.01	0.755	0.45	<0.001
Cardiovascular diseases (none)	−0.04	<0.001	0.77	<0.001	0.37	<0.001	0.09	<0.001	0.20	<0.001
CCI index score (0)										
1–2	0.10	<0.001	1.66	<0.001	0.31	<0.001	0.40	<0.001	0.32	<0.001
≥3	0.21	<0.001	3.33	<0.001	1.20	<0.001	1.00	<0.001	0.46	<0.001
Hospital accreditation level (community clinic)										
Medical centre	0.41	0.115	1.91	0.199	0.97	0.247	1.18	0.001	0.18	0.708
Regional hospital	0.36	0.160	1.79	0.246	0.82	0.325	0.95	0.007	−0.02	0.961
District hospital	0.32	0.207	1.63	0.332	0.63	0.450	0.86	0.015	−0.40	0.404
Hospital location (Kaohsiung/Pingtung and eastern region)										
Taipei and northern region	0.08	<0.001	1.32	<0.001	0.07	0.014	0.01	0.938	0.31	<0.001
Central and southern region	0.01	0.634	1.16	<0.001	0.14	<0.001	0.05	0.012	0.16	<0.001
Unclear	0.12	0.643	1.63	0.333	−0.17	0.836	0.15	0.676	0.56	0.248

*COCI is a dichotomous variable and transforms into two groups: high (above mean) and low (below mean).
CKD, chronic kidney disease; COCI, continuity of care index; ED, emergency department; GEE, generalised estimating equation.

group after intervention. This indicates that both group and time were important determinants of COCI and suggests that the intervention could result in increased COCI and closer renal status monitoring.

Early CKD is conventionally managed by conducting renal laboratory examinations. The mean frequency of renal laboratory examinations in the intervention group was 2.76 times per year, which met the goal of at least one examination every 6 months by the early-CKD programme and was significantly more than the 0.67 times per year recorded in the control group. The adequate number of examinations also suggested that the intervention group had a better understanding of their renal status. Many guidelines, such as the Kidney Disease Improvement Global Outcomes, suggest that patients receive CKD-related laboratory tests at least once a year to detect possible deterioration of renal functionality,[43] but for high-risk CKD groups, such as the elderly or patients with comorbidities, patients are recommended to check more frequently to detect renal deterioration in a timely manner. The early-CKD programme in Taiwan set a guideline to check laboratory data every 6 months. The results also serve as the key performance indicator for the programme. Studies discussing the use of outpatient utilisation services for people with multiple chronic conditions or those under a comprehensive care model have reported the significant effect of such care models.[44 45]

The increased medical expenses indicate more delicate renal care from increased COCI. The early-CKD programme also set many targets for controlling comorbidities, such as blood pressure, haemoglobin A1C, total cholesterol and low-density lipoprotein cholesterol. The increased medication expenses might have been caused by stricter control of the targets. Therefore, the higher expenses in the intervention group might have resulted from the programme, although it should be a necessary secondary prevention cost. Other studies have disagreed, finding that patient care via comprehensive care models

spent less on healthcare than usual care[45] or had no difference.[46] The outcome (use of emergency services and hospitalisation) failed to show any difference, probably because of the short follow-up time in this study.

Care model

Most current care models incorporate P4P incentives, multidisciplinary health providers and so on to better manage chronic diseases,[47–50] all of which improve continuity and quality of care, and emphasise patients' active role in disease management. Taiwan's government has launched an early-CKD programme that incorporates multidisciplinary health providers, provides health education to patients, reduces patients' 'shopping' behaviour and encourages continuous follow-ups. This model integrates multidisciplinary health providers to impose COC. We recommend encouraging patients to understand their illness and adhere to a healthy lifestyle to successfully manage their condition.[50]

Limitations

There are four major limitations of this study. First, it used claims data 1 year before and 1 year after the intervention, which reported very preliminary progress. A longer follow-up period is recommended for future studies. Second, the data were collated for the purpose of expense claims and are therefore missing some clinical information, such as CKD stage and laboratory data. However, this study used proxy variables to define the control group of patients with early CKD. Third, although we managed to include patients cared for by the same physicians, there were moderating variables (such as demographics, medication adherence, dietary adherence and lifestyle) that also affected health outcomes. There are also a number of reasons why some patients with CKD might not have enrolled in the MDC model, such as failure of physicians to notify patients about the programme, unavailability of dieticians/nurses during patients' visits and patient choice. Fourth, we were not able to generalise how healthcare providers educated their patients, which might have led to possible variance.

Conclusions

To face the huge burden and critical public health danger posed by CKD, many governments have tried to intervene during the pre-ESRD stage to stop progression to ESRD, but the general results have been unsatisfactory or controversial. Some governments are therefore intervening at an earlier stage. To tackle the problem, in 2011 Taiwan's NHIA launched an early-CKD programme in primary care settings using an MDC model. Participants had a much higher COC and visited health providers more frequently than non-participants. From the viewpoint of COC, the programme has had a positive effect.

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Collaborators CH Chiu is the major collaborator in this study.

Contributors Y-CC, S-FW, Y-CC and C-JW designed and conceived the study. S-FW and CC acquired and analysed the data set. Y-CC, S-FW, Y-JH, C-JW and CCH carried out the study and prepared the manuscript. CC and Y-CC responded to editorial and reviewers' comments. Y-CC and S-FW equally contributed to this study as first authors. All authors read and approved the final manuscript.

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