




Interdisciplinary collaboration and computer-assisted home healthcare referral in the emergency department: a retrospective cohort study

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Abstract

Aim Home healthcare (HHC) provides continuous care for disabled patients. However, HHC referral after the emergency department (ED) discharge remains unclear. Thus, this study aimed its clarification.

Methods A computer-assisted HHC referral by interdisciplinary collaboration among emergency physicians, case managers, nurse practitioners, geriatricians, and HHC nurses was built in a tertiary medical center in Taiwan. Patients who had HHC referrals after ED discharge between February 1, 2020 and September 31, 2020, were recruited into the study. A non-ED HHC cohort who had HHC referrals after hospitalization from the ED was also identified. Comparison for clinical characteristics and uses of medical resources was performed between ED HHC and non-ED HHC cohorts.

Results The model was successfully implemented. In total, 34 patients with ED HHC and 40 patients with non-ED HHC were recruited into the study. The female proportion was 61.8% and 67.5%, and the mean age was 81.5 and 83.7 years in ED HHC and non-ED HHC cohorts, respectively. No significant difference was found in sex, age, underlying comorbidities, and ED diagnoses between the two cohorts. The ED HHC cohort had a lower median total medical expenditure within 3 months (34,030.0 vs. 56,624.0 New Taiwan Dollars, $p=0.021$) compared with the non-ED HHC cohort. Compared to the non-ED HHC cohort, the ED HHC cohort had a lower ≤ 1 month ED visit, ≤ 6 months ED visit, and ≤ 3 months hospitalization; however, differences were not significant.

Conclusion An innovative ED HHC model was successfully implemented. Further studies with more patients are warranted to investigate the impact.

Keywords Computer · Emergency department · Home healthcare · Interdisciplinary

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Introduction

Aging is an important issue in public health worldwide. In the United States, the older population (≥ 65 years) was 16.9% in 2020 and projected to be 19.0% in 2025 [1]. In Taiwan, the older population is 16.2% in 2021 and projected to be 20% in 2025 [2]. In addition to rapid aging, a low birth rate is another important problem, and the effect of both contributed to a decreased population in Taiwan since 2020 [3]. Older adults are unable to seek medical care when necessary due to chronic and complex conditions, decreased family support, and increased disability [4]. Older patients who are disabled have prolonged hospitalization due to insufficient family support, which increased the burden of national health insurance [4]. Therefore, integrated home healthcare (HHC) was initiated in Taiwan in 2015 to provide convenient healthcare and decrease hospitalization stay due to social problems [4].

The emergency department (ED) is at the crossroad of home, hospitalization, ambulatory care, and long-term care facility [5]. Therefore, ED management greatly impacts the outcome of older patients [5]. The American College of Emergency Physicians suggests that ED provides a key opportunity for using less expensive and more convenient outpatient treatments in the older population [5]. HHC is always initiated by discharge planning during the patient's hospitalization and rarely at the ED. In the hospital-at-home program of the United States, patients are referred from the ED or inpatient hospital beds [6, 7]. The hospital-at-home care model in the United States included nurse and physician home visits, intravenous medications, point-of-care testing, remote monitoring, and video communication [7]. It is more advanced than the HHC model with only nurse and physician home visits and almost oral medications in Taiwan. A HHC model after ED discharge is not yet developed in Taiwan. In addition, the interdisciplinary collaboration between ED staff and HHC providers for patient referral and comparison of outcomes between ED HHC and HHC after hospital discharge remains unclear in the literature. Therefore, this study was conducted for its clarification.

Materials and methods

Study design, setting, and participants

This study was conducted in the Chi Mei Medical Center (CMMC), a tertiary medical center in Southern Taiwan. There were more than 60 full-time attending physicians and residents, serving for > 121,000 patients in the ED in the CMMC in 2019 [8]. The CMMC ED established a Chi Mei Integrated Geriatric Emergency Team in 2016 and the first Geriatric ED in Taiwan in 2019 to lead and improve geriatric care for the rapidly increasing older population

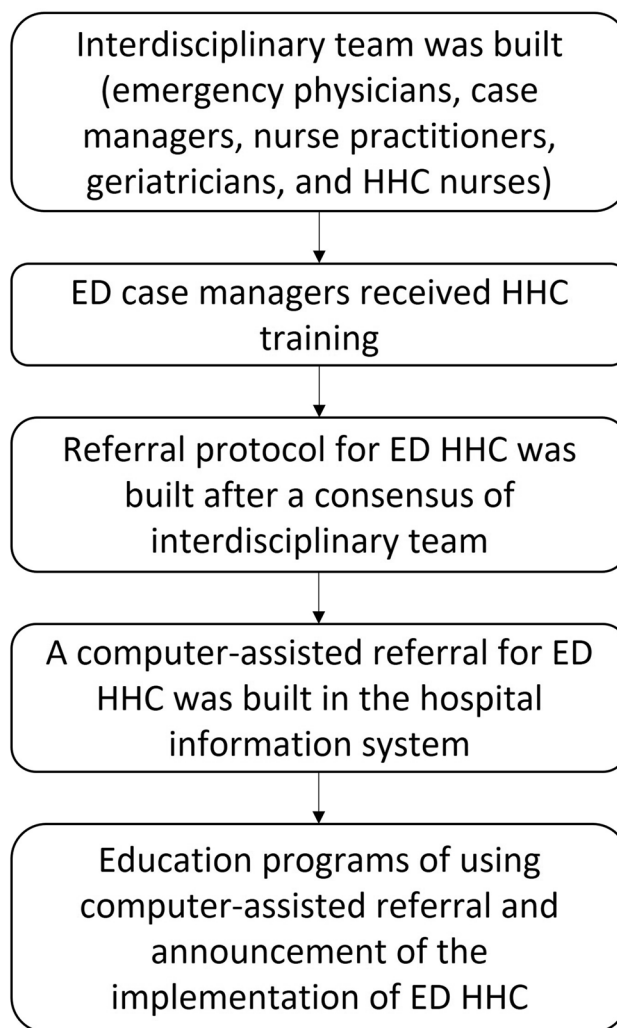


Fig. 1 Steps of the ED HHC model implementation. *ED* emergency department, *HHC* home healthcare

[9]. The Geriatric ED of CMMC implemented several studies and strategies to build the local data and solutions for the older population in Taiwan, including emergency medical services in the older population [10], geriatric syndromes and hospice care needs [11], a novel comprehensive screening tool (Emergency Geriatric Assessment) [12], computer-based and pharmacist-assisted medication review [13], and hospice and palliative care [14].

First, an interdisciplinary team was built, including ED staff (emergency physicians, ED case managers [also called transitional care nurses], and ED nurse practitioners) and HHC providers (geriatricians and HHC nurses) for implementing HHC after ED discharge in December 2019 (Fig. 1). Second, two ED case managers (both are registered nurses) received HHC training for 2 months to understand the HHC contents and get a close relationship with HHC providers. Third, a flowchart of computer-assisted

referral protocol for ED HHC was built after a consensus of the interdisciplinary team (Fig. 2). All patients in the ED, who fit all the following criteria, were candidates for ED HHC: (1) discharge from ED; (2) living at home (i.e., not a resident of long-term care facility); (3) disability or inconvenience for the hospital visits; and (4) < 30 min-drive between patient's home and hospital. Fourth, a computer-assisted ED HHC referral was built in the hospital information system (HIS) of ED (Supplementary Fig. 1). Fifth, educational programs using a computer-assisted referral for all the ED staff were initiated and the implementation of ED HHC was announced on January 1, 2020.

Data collection

Data of patients with a successful referral for ED HHC between February 1, 2020 and September 30, 2020, were retrospectively collected as the study cohort. A comparison cohort (non-ED HHC) was randomly selected from patients who received HHC discharged from the geriatric ward in CMMC between February 1, 2020 and September 30, 2020. The patients in non-ED HHC cohort were also from the ED. Data collection was performed by an experienced ED nurse practitioner who was blind to the outcomes of recruited patients. The study was not affected by COVID-19 because there was no pandemic during the study period in Taiwan.

Outcome measurements

Clinical characteristics, length of stay (LOS) in the index ED visit and hospitalization, expenditures of index ED visit, index hospitalization, and within 3 months after HHC referral and ED visit and hospitalization after HHC referral between two cohorts by the following 6 months were compared. The LOS in the ED is the duration of the stay in the ED. The expenditure was assessed from the patient's National Health Insurance application.

Ethical statements

This study was conducted after the approval of the institutional review board of the study hospital. All patient data were anonymized. Patient informed consent was waived due to the retrospective and observational nature of the study. The welfare of patients was not affected by the waiver.

Statistics

The Fisher's exact test was used for categorical variable analyses and the Mann–Whitney *U* test for continuous

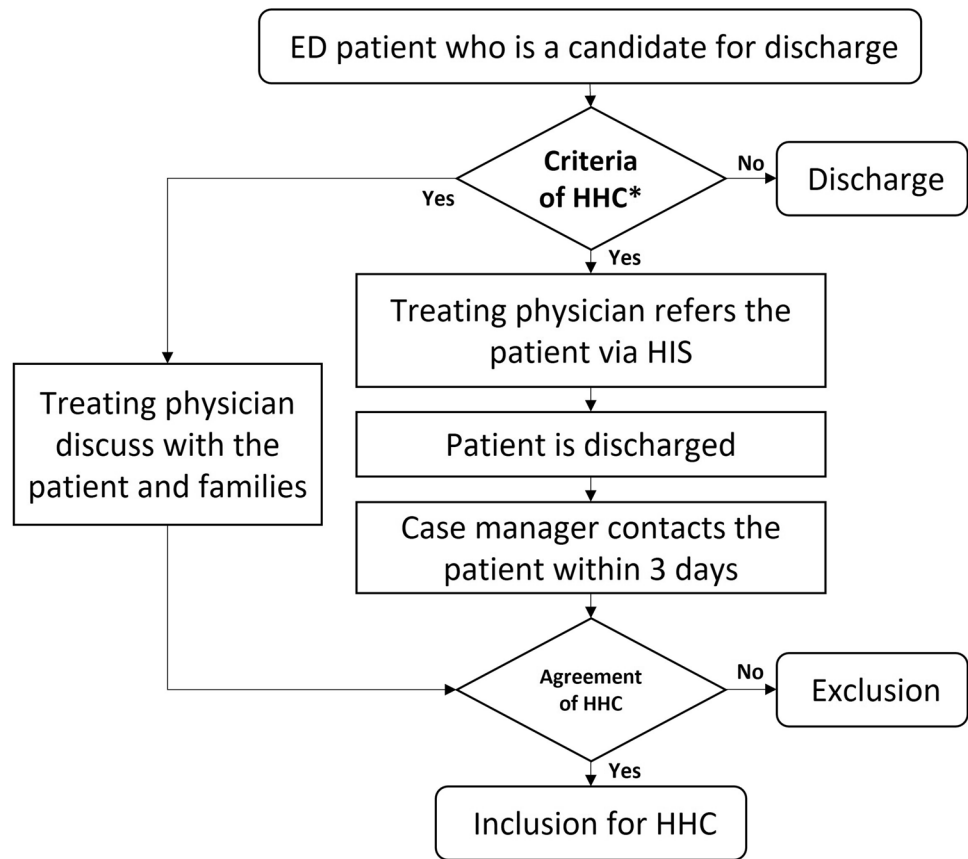
variables analyses. Logistic regression analyses were used to compare ED visits and hospitalization after HHC referral between patients in non-ED HHC and ED HHC cohorts. Statistical Analysis System 9.4 (SAS Institute Inc., Cary, NC, USA) was used for statistical analyses. The significance level was set at 0.05 (two-tailed).

Results

A model of ED HHC was successfully implemented in the CMMC. In total, 34 patients with ED HHC and 40 patients with non-ED HHC were identified in the study for comparison (Table 1). The mean age in the ED HHC and non-ED HHC was 81.5 and 83.7 years, respectively. The proportion of ≥ 85 years in the non-ED HHC cohort was higher than in ED HHC cohorts (50.0% vs. 35.3%); however, the difference among age sub-groups was not significant ($p = 0.431$). Most patients were triage 2 or 3 and non-traumatic causes in the index ED visits. We used the Taiwan Triage and Acuity Scale [15] for the ED triage, which was modified from the Canadian Emergency Department Triage and Acuity Scale [16]. The most common underlying comorbidities in the ED HHC cohort were hypertension (70.6%), followed by diabetes (61.8%), dementia (38.2%), cerebrovascular disease (38.2%), and chronic kidney disease (20.6%). All differences of underlying comorbidities between the two cohorts were not significant. The ED HHC cohort revealed 14.7% of patients with Foley indwelling, 2.9% with nasogastric feeding, 0% with a tracheostomy, 29.4% were bedridden, and 0% received hospice and palliative care. The most common ED diagnosis in the ED HHC cohort was urinary tract infection (50%), followed by fever (20.6%), delirium (8.8%), hyponatremia (5.9%), pneumonia (5.9%), femoral fracture (2.9%), weakness (2.9%), and acute kidney injury (2.9%). All differences in ED diagnoses between the two cohorts were not significant.

The LOSs in the index ED visit were not statistically different between the two cohorts (ED HHC: 28.7 ± 26.0 h vs. non-ED HHC: 25.1 ± 14.9 h, $p = 0.476$) (Table 2). Compared with the non-ED HHC cohort, the ED HHC cohort had a higher medical expenditure in the index ED visit (4363.6 ± 4074.2 New Taiwan Dollars [NTD] vs. 1179.4 ± 405.1 NTD, $p < 0.001$). However, the total hospitalization expenditure in the ED HHC cohort was zero since patients were discharged from the ED and received subsequent post-acute care by HHC. Compared with the non-ED HHC cohort, total medical expenditure within 3 months after referral for HHC was significantly lower in the ED HHC cohort (median: 34,030.0 NTD vs. 56,624.0 NTD). The ED visit ≤ 3 days after referral for HHC was 5.9% in the ED HHC cohort and 2.5% in the non-ED HHC cohort ($p = 0.591$). The numbers of ED visits after referral

Fig. 2 Flowchart of computer-assisted referral protocol for ED HHC. *All the four criteria were the candidates for ED HHC: (1) discharge from ED; (2) living at home (i.e., not a resident of long-term care facility); (3) disability or inconvenience for hospital visits; and (4) <30 min-drive between patient's home and hospital. *ED* emergency department, *HHC* home healthcare, *HIS* hospital information system



for HHC in ED HHC cohort were 0.4 ± 0.8 (mean \pm standard deviation) within 1 month, 0.8 ± 1.1 within 3 months, and 1.5 ± 2.8 within 6 months. No significant difference was found in the ED visit numbers after HHC referral between the two cohorts. The hospitalization of ≤ 14 days after HHC referral was 5.9% in the ED HHC cohort and 5.0% in the non-ED HHC cohort ($p > 0.999$). The number of hospitalizations after referral for HHC in the ED HHC cohort was 0.5 ± 0.8 within 3 months and 0.8 ± 1.1 within 6 months. No significant difference was found in the hospitalization number after HHC referral between the two cohorts.

Compared with non-ED HHC, logistic regression showed that the ED HHC cohort had fewer ED visits within 1 month [adjusted odds ratio (OR): 0.1; 95% confidence interval (CI) 0–4.3] and within 6 months (adjusted OR 0.1; 95% CI 0–3.6) after HHC referral; however, the difference was not significant (Table 3). The number of hospitalizations within 3 months was fewer in the ED HHC cohort than in the non-ED cohort (adjusted OR 0.004; 95% CI <0.001–12.8); however, the difference was not significant.

Discussion

This study showed that ED HHC model implementation is practical with ED staff and HHC provider collaboration. A computer-assisted tool via HIS made the HHC referral more convenient for all ED staff. The total medical expenditure within 3 months after HHC referral was significantly lower in the ED HHC cohort than in the non-ED HHC cohort. The ED HHC cohort showed fewer ED visits within 1 month, ED visits within 6 months, and hospitalizations within 3 months compared to the non-ED HHC cohort; however, logistic regression showed that the differences were not significant. The most common ED diagnosis in the ED HHC cohort was urinary tract infection, followed by fever, delirium, hyponatremia, pneumonia, femoral fracture, weakness, and acute kidney injury.

The ED HHC model fits the gap of care continuity for patients who are disabled and provides convenient post-acute care to help their families [17]. The most common obstacle for the ED HHC is the lack of HHC education of ED staff [17]. In addition, ED staff are prone to make disposition decisions for patients as soon as possible due to the busy and often crowded ED environment. If the ED HHC referral is inconvenient for the ED staff, it will not become an option for their disposition decisions [17]. To minimize

Table 1 Comparison of demographic data and clinical characteristics between patients in non-ED HHC and ED HHC

Variables	Non-ED HHC (<i>n</i> = 40)	ED HHC (<i>n</i> = 34)	<i>p</i> value*
Sex			0.633
Female	27 (67.5)	21 (61.8)	
Male	13 (32.5)	13 (38.2)	
Age (mean ± SD)	83.7 ± 8.5	81.5 ± 9.5	0.313
Age subgroup			0.431
65–74 years	7 (17.5)	9 (26.5)	
75–84 years	13 (32.5)	13 (38.2)	
≥ 85 years	20 (50.0)	12 (35.3)	
ED Triage (%) ^a			0.637
1	0	1 (2.9)	
2	20 (50.0)	15 (44.1)	
3	20 (50.0)	18 (52.9)	
4&5	0	0	
Trauma or non-trauma (%)			0.458
Non-trauma	37 (92.5)	29 (85.3)	
Trauma	3 (7.5)	5 (14.7)	
Underlying comorbidity (%)			
Hypertension	34 (85.0)	24 (70.6)	0.163
Diabetes	20 (50.0)	21 (61.8)	0.354
Dementia	20 (50.0)	13 (38.2)	0.354
Cerebrovascular disease	10 (25.0)	13 (38.2)	0.314
Chronic kidney disease	10 (25.0)	7 (20.6)	0.784
Malignancy	2 (5.0)	6 (17.7)	0.132
Coronary artery disease	11 (27.5)	4 (11.8)	0.146
Chronic obstructive pulmonary disease	5 (12.5)	4 (11.8)	> 0.999
Congestive heart failure	3 (7.5)	2 (5.9)	> 0.999
Liver cirrhosis	0	1 (2.9)	0.460
Iatrogenesis (%)			
Nasogastric feeding	4 (10.0)	1 (2.9)	0.366
Foley indwelling	6 (15.0)	5 (14.7)	> 0.999
Tracheostomy	1 (2.5)	0	> 0.999
Bedridden (%)	9 (22.5)	10 (29.4)	0.596
Hospice and palliative care (%)	1 (2.5)	0	> 0.999
ED diagnosis (%)			
Urinary tract infection	17 (42.5)	17 (50.0)	0.641
Fever	13 (32.5)	7 (20.6)	0.300
Delirium	6 (15.0)	3 (8.8)	0.494
Hyponatremia	6 (15.0)	2 (5.9)	0.275
Pneumonia	3 (7.5)	2 (5.9)	> 0.999
Fracture of femur	6 (15.0)	1 (2.9)	0.116
Weakness	5 (12.5)	1 (2.9)	0.209
Acute kidney injury	2 (5.0)	1 (2.9)	> 0.999
Limb cellulitis	3 (7.5)	0	0.245
Urosepsis	2 (5.0)	0	0.497
Hyperglycemia	2 (5.0)	0	0.497
Vertigo	2 (5.0)	0	0.497

ED emergency department, HHC home healthcare, SD standard deviation

*Categorical variables analysis by the Fisher's exact test and continuous variables analysis by the Mann–Whitney *U* Test

^aWe used the Taiwan Triage and Acuity Scale [15] for the ED triage, which was modified from the Canadian Emergency Department Triage and Acuity Scale [16]

Table 2 Comparison of LOS, expenditure, and ED visit and hospitalization after HHC referral between patients in non-ED HHC and ED HHC

Outcome	Non-ED HHC (<i>n</i> = 40)	ED HHC (<i>n</i> = 34)	<i>p</i> value*
LOS (mean ± SD)			
LOS in ED/hour	25.1 ± 14.9	28.7 ± 26.0	0.476
LOS in hospital/hour	237.0 ± 189.0	0	–
Expenditure ^a			
Expenditure in ED (mean ± SD)	1179.4 ± 405.1	4363.6 ± 4074.2	< 0.001
Total expenditure of hospitalization (mean ± SD)	63,274.1 ± 113,267.5	0	–
Total medical expenditure within 3 months after referral for HHC (mean ± SD)	114,974.2 ± 183,993.7	68,726.0 ± 93,320.7	0.169
Total medical expenditure within 3 months after referral for HHC (median, IQR)	56,624.0 (35,408–85,293.5)	34,030.0 (10,635.0–82,001.0)	0.021
ED visit after referral for HHC			
≤ 3 days, <i>n</i> (%)	1 (2.5)	2 (5.9)	0.591
≤ 1 month (mean ± SD)	0.4 ± 0.7	0.4 ± 0.8	0.590
≤ 3 months (mean ± SD)	0.7 ± 1.2	0.8 ± 1.1	0.883
≤ 6 months (mean ± SD)	1.1 ± 1.6	1.5 ± 2.8	0.439
Hospitalization after referral for HHC			
≤ 14 days, <i>n</i> (%)	2 (5.0)	2 (5.9)	> 0.999
≤ 3 months (mean ± SD)	0.6 ± 1.0	0.5 ± 0.8	0.632
≤ 6 months (mean ± SD)	0.9 ± 1.5	0.8 ± 1.1	0.708

LOS length of stay, ED emergency department, HHC home healthcare, SD standard deviation, IQR interquartile range

*Categorical variables analysis by the Fisher's exact test, continuous variables analysis by the Mann–Whitney *U* Test

^aExpenditure was counted by New Taiwan Dollars

Table 3 Comparison for ED visit and hospitalization after referral for HHC between patients with non-ED HHC and ED HHC by logistic regression analyses

Outcome [ED HHC vs. non-ED HHC (reference)]	Crude OR (95% CI)	<i>p</i> value	Adjusted OR* (95% CI)	<i>p</i> value
ED visit after referral for HHC				
≤ 3 days	2.0 (0.3–16.6) ^a	0.511	1.0 (0–479.1) ^a	> 0.999
≤ 1 month	1.1 (0.4–3.0)	0.856	0.1 (0–4.3)	0.206
≤ 3 months	1.2 (0.5–3.0) ^a	0.751	1.0 (0.1–12.1) ^a	> 0.999
≤ 6 months	2.0 (0.8–5.0)	0.152	0.1 (0–3.6)	0.191
Hospitalization after referral for HHC				
≤ 14 days	1.2 (0.2–7.5) ^a	0.857	1.0 (0.01–217.7) ^a	> 0.999
≤ 3 months	1.0 (0.4–2.6)	0.989	0.004 (< 0.001–12.8)	0.613
≤ 6 months	1.7 (0.7–4.2)	0.281	2.4 (0.02–290.6)	0.726

ED emergency department, HHC home healthcare, OR odds ratio, CI confidence interval, NA not applicable

*Multiple models adjusted by sex, age, LOS in ED, LOS in hospitalization, expenditure in ED, expenditure in hospitalization, ED triage, trauma or non-trauma, hypertension, diabetes, dementia, cerebrovascular disease, coronary artery disease, chronic kidney disease, chronic obstructive pulmonary disease, iatrogenesis, bedridden, and total expenditure within 3 months

^aFirst logistic regression

the obstacles of HHC referral, dedicated case managers were employed, a computer-assisted referral tool in the HIS was built, and educational programs were provided for all the ED staff in this model. If the ED staff had enough time and HHC knowledge, the referral is directly initiated by the treating physician while the patient remains in the ED (Fig. 2).

Contrarily, the referral is initiated by pressing the referral button in the HIS when the ED staff does not have enough time or referral knowledge. After the patient is discharged, a dedicated case manager will contact the patient and families to discuss the possibility of subsequent HHC.

Close collaboration between the ED staff and HHC providers also plays an important role in the ED HHC model success [18]. In addition to building an interdisciplinary team and HHC training of ED case managers, the following efforts were made to achieve close collaboration: (1) emergency physician who oversees the model and case managers join the HHC monthly meetings; (2) geriatrician who provides HHC join the handover meeting in the ED every morning and visit patients observed in the ED; and (3) real-time team communication using communication software (Supplementary Table 1). Computer-assisted tool via HIS made the HHC referral more convenient that increased the will of ED staff referral. A previous study reported that the lack of real-time referral discussion between the case managers and patients and/or families limited the ED HHC referral [19]. The patient in our model was discharged after the initiation of computer-assisted referral and the case manager will contact the patient and/or families for arranging the HHC later, which increases referral success.

In addition to providing a convenient method for post-acute care and subsequent long-term care for patients who are disabled, our ED HHC model showed a lower total medical expenditure within 3 months than patients who received HHC after hospitalization. The finding suggests that the ED HHC model does not only help patients who are not hospitalized but need medical care, but also lower the medical cost, leading to a win–win situation. The ED visit within 1 month, ED visit within 6 months, and hospitalizations within 3 months in the ED HHC cohort were fewer than the non-ED HHC cohort; however, the difference was not significant. The possible explanation is the small sample size. Recruiting more patients for comparison is necessary to clarify this issue.

ED HHC nature is a kind of post-acute care; however, the HHC also becomes chronic care since those receiving HHC have a disability and often multiple chronic comorbidities. Particularly, the ED HHC completes the continuity of patient care, including post-acute care, and bridges chronic care according to patient needs. The HHC in Taiwan is different from the model of hospital-at-home in the United States. The HHC in Taiwan includes patients who need main chronic care. Therefore, their medications are almost all in oral form, different from the intravenous medication in the acute care of hospital-at-home. In other countries, hospital-at-home provides hospital-level care in patient homes as an in-hospital stay substitute [7, 20]. The index diseases in the HHC in Taiwan are less severe than patients receiving hospital-at-home in the United States due to medical care limitations.

The major strength of this study is the successfully implemented first ED HHC model in Taiwan, which has become an important reference for interdisciplinary collaboration between ED and HHC worldwide. The major

limitation is the small sample size, which could not reflect the actual difference between ED HHC and non-ED HHC. Further study by recruiting more patients is undergoing in our hospital to clarify this issue. Another limitation is this model may not be generalized to other hospitals or nations due to different medical resource and insurance. Modification of the model may be needed if other hospital wants to adopt this model.

Conclusion

The first ED HHC model was successfully implemented in Taiwan to be an important reference for interdisciplinary collaboration between the ED staff and HHC providers. Educational programs for all the ED staff, close communication with the interdisciplinary team members, and computer-assisted tool via HIS for referral are important factors for the success. Total medical expenditure within 3 months was lower in the ED HHC cohort than in the non-ED HHC cohort, which suggests that patients who fit the HHC criteria may be better to be directly referred from the ED instead of HHC after hospitalization. Medical resource use, including subsequent ED visits and hospitalization after index ED visits, needs more data for future clarification.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s40520-022-02109-9>.

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Author contributions SLH, KTT, SPH, and CC Huang designed and conceived this study and wrote the manuscript. THT, PCY, CC Hsu, and HJL assisted the implementation and wrote the manuscript. CHH performed the statistical analysis and wrote the manuscript. All authors read and approved the final manuscript.

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Availability of data and material The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest Authors declare no conflicts of interest.

Ethics approval and consent to participate This study was conducted according to the Helsinki Declaration after the approval of the institutional review board of the study hospital. All patient data were anonymized. Patient informed consent was waived due to the retro-

spective and observational nature of the study. The welfare of patients was not affected by the waiver.

Consent for publication Not applicable.

Impact statement We certify that this work is novel of recent novel clinical research.

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