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Effectiveness of a 5-year health empowerment programme on promoting cardiovascular health for adults from low-income families in Hong Kong

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ABSTRACT

Objective: This study aimed to evaluate the effectiveness of a health empowerment programme (HEP) to enhance cardiovascular health for adults from low-income families.
Methods: A prospective cohort study ($N = 219$, Intervention group: $n = 103$, comparison group: $n = 116$) was conducted with participants recruited from January 2013 to November 2015 and followed up until January 2022. Throughout the study duration, intervention group were invited to participate in the HEP. The cardiovascular health status of both groups at baseline and follow-up were assessed using the adapted Ideal Cardiovascular Health Index (ICHI) defined by the American Heart Association. After inverse propensity score weighting, multiple linear regression and Poisson regression were employed to examine the effects of the HEP.
Results: The HEP was associated with a greater increase in ICHI total score ($B = 0.33$, $p < 0.001$), and the increase of proportion of people achieving a normal blood pressure (Incidence rate ratio: 3.39, $p < 0.05$).
Conclusion: HEP can be an effective and sustainable strategy to reduce social disparities in cardiovascular health of adults from low-income families, as indicated by improvement in the ICHI total score and blood pressure status.
Practical Implications: The sustainable HEP in the community setting has potential for generalizability and scalability to other financially challenged families.

1. Introduction

Cardiovascular diseases (CVDs) are leading causes of morbidity and premature deaths worldwide [1]. It also imposes significant life-years lost, reduced quality of life, and direct and indirect medical costs [2,3]. To promote and monitor cardiovascular health, the American Heart Association (AHA) defined ideal cardiovascular health (ICH) as having four ideal health behaviors (nonsmoking, active physical activity, normal body mass index, and a healthy diet) and three ideal health factors (normal blood pressure, total cholesterol, and plasma glucose levels) [4]. Several population-based studies have found that the prevalence of ICH remains low [5–7], particularly among low-income individuals who struggle with basic amenities and have limited access to socioeconomic and healthcare resources [8]. In fact, people with low socioeconomic status bear a significant burden of CVDs, being more likely to experience increased event rates and worse outcomes [9–11]. Therefore, efforts to develop effective interventions that can improve cardiovascular health for those living in poverty are crucial to reduce the social disparity in health [12].

One significant barrier to the promotion of ICH, particularly for low-income families, is limited health literacy and access to healthcare provider [12]. An effective community-based strategy solving this problem is health empowerment (HE), which is defined as raising individuals' awareness of their capacity to gain greater control over their

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lives and make decisions about their health [13]. HE involves supporting individuals, families, and communities in enhancing health knowledge, motivation, self-assurance, utilization of health resources, and self-care to maintain health [14]. A growing body of evidence has shown that HE interventions can help improve cardiovascular health in different vulnerable populations [15–17]. The HE interventions reported in existing literature tend to include components such as education [18,19], counseling or support [20,21], and exercise sessions [22–24]. These HE interventions are typically controlled, delivered by health professionals [25], focus on individual cardiovascular health risk factors such as eating habits [26] and physical activity level [24], and are exclusively targeted at either parents [27] or adolescents [28]. These limitations affect generalizability, scalability, and sustainability.

To translate research evidence to practice, we implemented a long-term, complex, community-based health empowerment Programme (HEP) that integrated services and resources from non-governmental organizations (NGOs), health service providers, and academic researchers for 200 low-income families in a district in Hong Kong [29]. The HEP's integrated components included annual health assessments, health literacy talks, self-care enablement courses, and health ambassador training, all of which were accessible to both parents and children of the target families in their natural environment on a voluntary basis. This study aimed to evaluate the effects of HEP on cardiovascular health. We hypothesized that the HEP would be associated with improved cardiovascular health over a 5-year follow-up period among adults from low-income families.

The study was carried out in Hong Kong, an Asian region grappling with health disparities. Despite being a high-income area for centuries, 23.6% of Hong Kong's population still lives in poverty based on local criteria (<50% of median income) [30]. The city's high cost of living, including private medical expenses, and insufficient public healthcare resources, leave low-income families struggling to meet their basic living and health needs [31,32]. CVDs are among the leading causes of morbidity and mortality in Hong Kong [33,34], with direct and indirect medical costs exceeding HKD $60 billion annually [35]. It is estimated that middle-aged residents have an 11.4% chance of developing CVDs in the next decade [36]. Research on disparities in cardiovascular health is particularly relevant in Hong Kong, as the association between socioeconomic status, premature death, and CVDs risk is stronger in Asian than Western populations [37].

Tung Chung, a district on a remote island of Hong Kong with a 40% poverty rate among residents [38], exemplifies the coexistence of poverty and insufficient public healthcare services. A local philanthropic group launched the Trekkers Family Enhancement Scheme (TFES) in 2012, assisting 200 financially disadvantaged households in Tung Chung. The scheme aims to enable families to develop their full potential through the provision of opportunities in healthcare, education, employment, and family/environmental harmony [29]. Families in the TFES can access supportive services in parenting, children's tuition, and youth group activities organized by NGOs (see Supplementary Table 1 for details). The HEP in this study was launched in 2013 as the healthcare component of the TFES. When this study began, the district had only one public primary care clinic and a newly opened public district hospital [39] serving 78,000 residents [40].

2. Method

2.1. Study design and subject recruitment

This was a prospective cohort study that compared the ICH of two groups of low-income families with young children in Grades 1–3. All families in TFES were eligible and invited to participate in the HEP (referred to as "intervention families"), and a comparison group was selected from families in Tung Chung and Kwai Chung who did not join TFES. Kwai Chung is a suburban community that has similar sociodemographic characteristics as that of Tung Chung [30]. Participants were recruited between January 15, 2013, and November 30, 2015. Families were eligible if they met the following criteria: (1) At least one family member was employed, either full-time or part-time, (2) had a child enrolled in a primary school programme for Grades 1 to 3, (3) had a monthly household income that did not exceed 75% of the median monthly household income in Hong Kong (e.g.16,500HKD [2135 USD] for a family of three in 2013), and (4) provided written consent. During the five-year follow-up, intervention families were offered regular HEP activities and could participate if they wished. Meanwhile, families in the comparison group were not invited to participate in the intervention activities. The study received ethical approval from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 12–517).

2.2. Study intervention – The HEP

The HEP incorporated yearly health assessment, health literacy courses, health enablement activities, and health ambassadors training. The health assessment consisted of an annual phone survey on health and healthcare utilization, clinical health assessments, and a Health Hotline, accessible to both adults and their children. The assessments were conducted by a team of research nurses, technicians, and trained research assistants with strict adherence to the assessment protocol. Individuals with significant health problems were immediately referred to appropriate services after their assessment results were available. Those with health risks (e.g. overweigh) were counselled by our nurses by telephone within one month of the assessment results, and were sent specific healthy lifestyle advices by text messages once every two weeks. The annual number of individuals with significant health problems/risks and the referrals they received are listed in Supplementary Table 2. The health hotline was answered by a member of the project team during office hours, and nurses and doctors were available to answer calls at designated times. A telephone recording of messages was taken for calls received after office hours, and nurses ensured that calls or messages were returned within 72 h.

The Health Literacy Program provided health knowledge on common problems identified from the health assessment component. It comprised health talks and seminars on topics likes healthy eating, weight management, benefits of exercise, liver diseases, nutrition, stress management, psychosomatic illnesses in children, and normal child development. Participants' knowledge specific to the health topic before and after each seminar was evaluated and shown significant increase. The Self-Care Enablement Program included workshops and consultations delivered by specialists or professionals, covering stress management, nutrition, and exercise. The details of these activities are shown in Supplementary Tables 3 and 4. The Self-Care Enablement Program also developed a mobile App, *Family Move*, to provide off-class coaching to involve both the adult and their children.

Health Ambassador Program trained adults to advise others on health issues. During nutrition or exercise workshops and courses in the Self-Care Enablement Program, some participants were trained to coordinate group practices and promote healthy lifestyle among their families and peers.

2.3. Outcome measures

Seven metrics of ideal cardiovascular health index (ICHI) were adapted from those defined by the AHA: never smoked or quit smoking for 12 months or longer, BMI less than 23 kg/m^2, active physical activity (at least 150 min/week moderate intensity or 75 min/ week vigorous intensity or 150 min/week moderate plus vigorous intensity), fruit and vegetable intake of at least 5 servings, total cholesterol less than 200 mg/dL, blood pressure less than 120/80 mm Hg, and fasting plasma glucose level less than 100 mg/dL. The definitions of the ICHI of this study and those of the AHA are presented in Supplementary Table 5. We defined an ideal BMI with a cutoff point of less than 23 kg/m^2, which is

the standard for Asian individuals [41]. Additionally, we used fruit and vegetable intake as a proxy indicator of a healthy diet because data on whole grain and sodium consumption were not collected. We defined healthy eating based on the Hong Kong Centre for Health Promotion recommendation of consuming five portions of vegetables and fruits per day [42]. A value of 1 was assigned for each ICHI metric if the criterion for ideal cardiovascular health was met. Otherwise, if the criterion was not met, a value of 0 was assigned. Then, the scores on all ICHI metrics were summed to form the total score of ICHI, which ranges from 0 to 7, with a higher score indicates a better cardiovascular health, and a total ICHI score equals or larger than 5 is regarded as ICH [4].

The health factors of ICHI were determined through laboratory tests administered by registered nurses, and questionnaire surveys conducted by trained interviewers in person or by telephone. The questionnaire surveys also collected data on socio-demographics and health status.

2.4. Statistical analyses

We employed intention-to-treat approach, incorporating all participants who had baseline and follow-up assessments information in the analysis. All statistical analyses were conducted using STATA version 16.0 (StataCorp LP, College Station, TX, USA). We considered two-tailed tests of significance, with p values less than 0.05 indicating statistical significance.

Descriptive statistics (i.e., numbers and percentages) were utilized to display participants' baseline characteristics. A multivariable logistic regression conditional on all baseline covariates was applied to calculate propensity score (PS) of all participants. Inverse probability of treatment weighting (IPTW) using the PS was performed, followed by truncation of the 1st and 99th percentiles of the observed PS weighting distribution to account for extreme weights. The following baseline covariates were taken into consideration: participants' age, gender, diagnosed chronic diseases by a doctor, marital status, monthly household income, reception of governmental comprehensive social security assistance and ICHI total score at baseline. Standardized mean differences (SMDs) of baseline covariates between intervention and comparison groups were calculated to estimate the baseline characteristics balance between two groups, with SMD < 0.1 indicating optimal balance (Table 1).

After IPTW, we employed a multiple linear regression to identify the independent effect of the HEP on participants' changes in the total score of ICHI from baseline to the 5-year follow-up. For the model, we report the R^2 and F-test of overall significance. We also report the unstandardized coefficients (B), 95% confidence interval (CI), and p-value, which indicate the intervention's effects on the 5-year change of total ICHI score. Moreover, Poisson regression after IPTW was used to examine the HEP's independent effect on the proportion of participants with improvements in each ICHI metrics. We reported the incidence rate ratio (IRR), 95% CI of IRR, 95% CI of unstandardized coefficients (B) and p-value, which indicate the intervention's effects on the 5-year changes of each ICHI metric. Post-hoc powers for the 5-year change in total ICHI score and the proportion of participants with improvements in each ICHI metrics were calculated via using current sample size.

To evaluate the robustness of our results, we conducted three sensitivity analyses that: (1) performed a multiple linear regression controlling covariates without IPTW to see the independent effect of HEP; (2) included only participants who were followed up for more than 24 months in both groups; and (3) included only participants who were followed up for more than 36 months in both groups.

Table 1
Baseline characteristics of participants before and after propensity score weighting.

	Before propensity score weighting				After propensity score weighting			
	Total ($N = 219$)	Intervention group ($N = 103$)	Comparison group ($N = 116$)	SMD	Total ($N = 219$)	Intervention group ($N = 103$)	Comparison group ($N = 116$)	*SMD*
Age, mean (SD) year	$N = 219$ 41.02(6.83)	$n = 103$ 40.33(7.01)	$n = 116$ 41.63(6.64%)	0.19	$N = 219$ 41.06(7.12)	$n = 103$ 40.85(7.92)	$n = 116$ 41.28(6.21)	.061
Gender (%, *n*)	$N = 219$	$n = 103$	$n = 116$	0.15	$N = 219$	$n = 103$	$n = 116$	.013
Female	161 (73.52%)	72(69.90%)	89(76.72%)		160 (73.13%)	76(73.41%)	84(72.84%)	
Male	58(26.48%)	31(30.10%)	27(23.28%)		59(26.87%)	27(26.59%)	32(27.16%)	
Educational level (%)	$N = 219$	$n = 103$	$n = 116$	0.35	$N = 219$	$n = 103$	$n = 116$	.006
No higher education	202 (92.24%)	100(97.09%)	102(87.93%)		202 (92.17%)	95(92.25%)	107(92.08%)	
Higher education (Tertiary/Further education)	17(7.76%)	3(2.91%)	14(12.07%)		17(7.83%)	8(7.75%)	9(7.92%)	
Working status (%)	$N = 219$	$n = 103$	$n = 116$	0.26	$N = 219$	$n = 103$	$n = 116$	.016
Working (employee or employer)	104 (47.49%)	56(54.37%)	48(41.38%)		105 (47.90%)	50(48.29%)	55(47.50%)	
Not working (home maker, retired, unemployment)	115 (52.51%)	47(45.63%)	68(58.62%)		114 (52.10%)	53(51.71%)	61(52.50%)	
Marital status (%)	$N = 219$	$n = 103$	$n = 116$	0.20	$N = 219$	$n = 103$	$n = 116$	.004
Married	183 (47.49%)	90(87.38%)	93(80.17%)		183 (83.45%)	86(83.53%)	97(83.38%)	
Unmarried (single/ widower)	36(16.44%)	13(12.62%)	23(19.83%)		36(16.55%)	17(16.47%)	19(16.62%)	
Monthly family income[#] (%), HKD	$N = 219$	$n = 103$	$n = 116$	0.11	$N = 219$	$n = 103$	$n = 116$	.017
$< 11{,}000$	83(37.90%)	42(40.78%)	41(35.34%)		81(36.91%)	38(37.30%)	42(36.50%)	
$> =11{,}000$	136 (62.10%)	61(59.22%)	75(64.66%)		138 (63.09%)	65(62.70%)	74(63.50%)	
Government assistance reception	$N = 219$	$n = 103$	$n = 116$	0.06	$N = 219$	$n = 103$	$n = 116$	.013
Yes	41(18.72%)	18(17.48%)	23(19.83%)		42(19.00%)	20(19.24%)	22(18.74%)	
No	178 (81.28%)	85(82.52%)	93(80.17%)		177 (81.00%)	83(80.76%)	94(81.26%)	
History of chronic morbidity	$N = 219$	$n = 103$	$n = 116$	0.06	$N = 219$	$n = 103$	$n = 116$	.020
Yes	101 (46.12%)	46(44.66%)	55(47.41%)		104 (47.39%)	48(46.89%)	56(47.89%)	
No	118 (53.88%)	57(55.34%)	61(52.59%)		115 (52.61%)	55(53.11%)	60(52.11%)	

Note. SD = Standard deviation. The total % may not add up to 100% because of rounding; * #the averaged HK population median monthly household income in 2012-2015 was around HKD 22,000

3. Results

A total of 251 adults from 192 families were enrolled to the study between January 2013 and November 2015, with 242 (120 in intervention group and 122 in control group) adults gave written consent to participate. Of these, 219 (94%) participants completed both the baseline and the 5-year follow-up assessments till January 2022 (Follow-up period: Mean 6.12 years; Median: 5.98 years). Among all eligible participants, 103 participants (Follow-up period: Mean 6.46 years; Median: 6.55 years) were in the intervention group, while 116 participants (Follow-up period: Mean 5.81 years; Median: 5.53 years) were in the comparison group. The attrition rate was 14.17% and 11.45% in the intervention and comparison groups, respectively. For all the activities in the Health Literacy Program and the Self-Care Enablement Program, participants expressed significantly better self-care enablement after participation, and over 90% of participants were satisfied and would recommend the activity to their family and friends. Fig. 1 illustrates the selection process flow.

3.1. Participant characteristics

Table 1 displays the baseline characteristics by groups before and after PS weighting. Overall, the participants had a mean age of 41.06 (SD = 7.12) at baseline, with 73.13% being female. Majority of participants (89.50%) had a monthly household income below the averaged Hong Kong population median monthly household income for a family of three people (22,000HKD), and 36.91% of participants had a monthly household income less than half of the of the median income (11,000 HKD). A majority of participants did not receive governmental assistance (81.00%). All demographic characteristics were balanced between two groups after PS weighting, as indicated by SMD < 0.1.

3.2. The change in the total score of ICHI at baseline and 5-year follow-up

Fig. 2 depicts the distribution of the total scores of ICHI at baseline (For intervention families, M= 4.02, SD = 1.09; For comparison families, M= 4.03, SD = 1.07) and the 5-year follow-up (For intervention families, M= 4.36, SD = 1.37; For comparison families, M= 4.03, SD =1.2) by groups. At baseline, the percentage of participants with total scores equal to or greater than 5 (i.e., the threshold of ICH) was lower in the intervention group (36%) compared to the comparison group (36.3%). However, at the 5-year follow up, the percentage of ICH was higher in the intervention group than the comparison group at the 5-year follow-up (43.7% vs. 32.7%). The multiple linear regression analysis after IPTW revealed a significant relationship between the HEP and an increase in ICHI total score at the 5-year follow-up (B = 0.33, $p < 0.001$, post-hoc power = 0.71) (Table 2).

3.3. The change in the individual metric of ICHI at baseline and 5-year follow-up

Table 3 illustrates that the proportion of participants in the intervention group with ideal BMI status at baseline (41.20%) is similar to that at 5-year follow-up (41.57%). While the number of participants with ideal BMI scores in the comparison group decreased at the 5-year follow-up (from 39.01% to 29.56%). The number of participants with ideal diet status increased in both the intervention group (from 9.92% to 31.81%) and the comparison group (from 5.67% to 23.51%), although the percentage of participants with an ideal diet was consistently higher in the intervention group. All participants in both intervention and comparison groups had ideal total cholesterol levels at baseline and follow-up. Furthermore, the percentage of participants with ideal blood pressure increased in the intervention group (from 64.33% to 68.60%) while it decreased in the comparison group (from 67.44% to 58.28%). The percentage of individuals with ideal glucose level declined in the

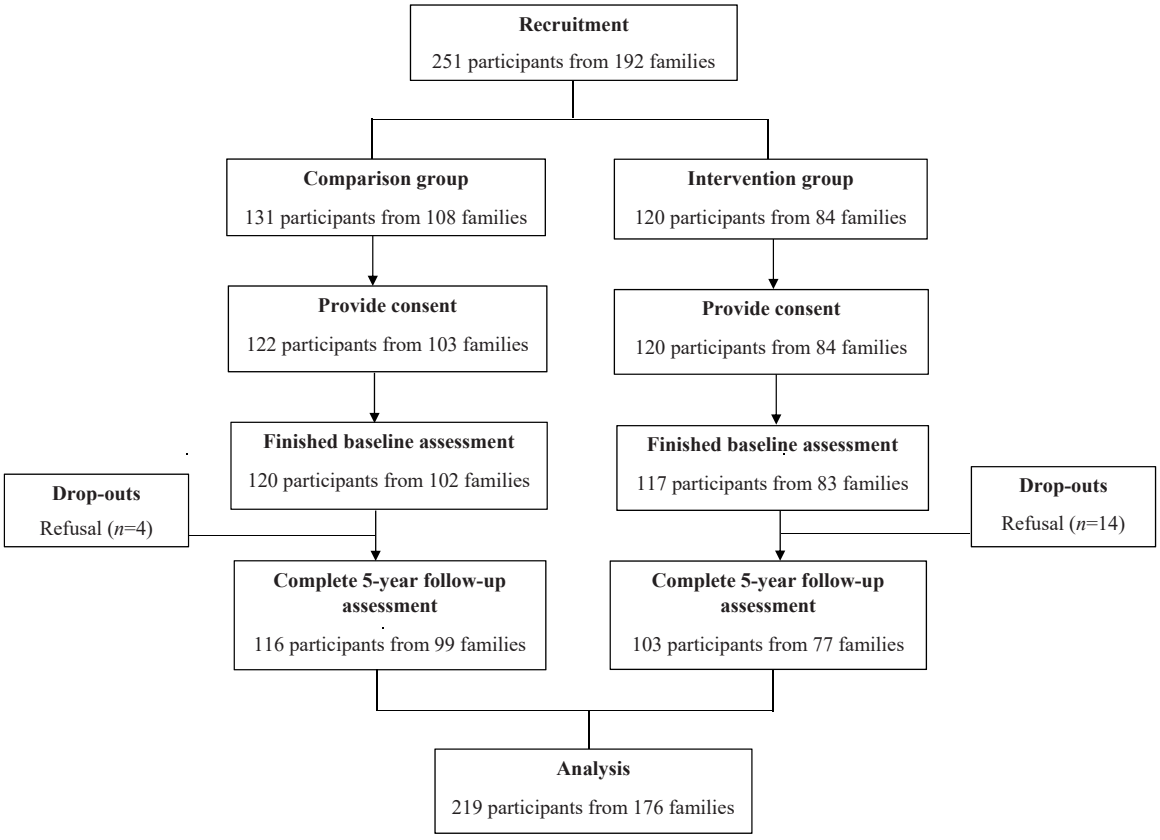

Fig. 1. Subject flowchart.

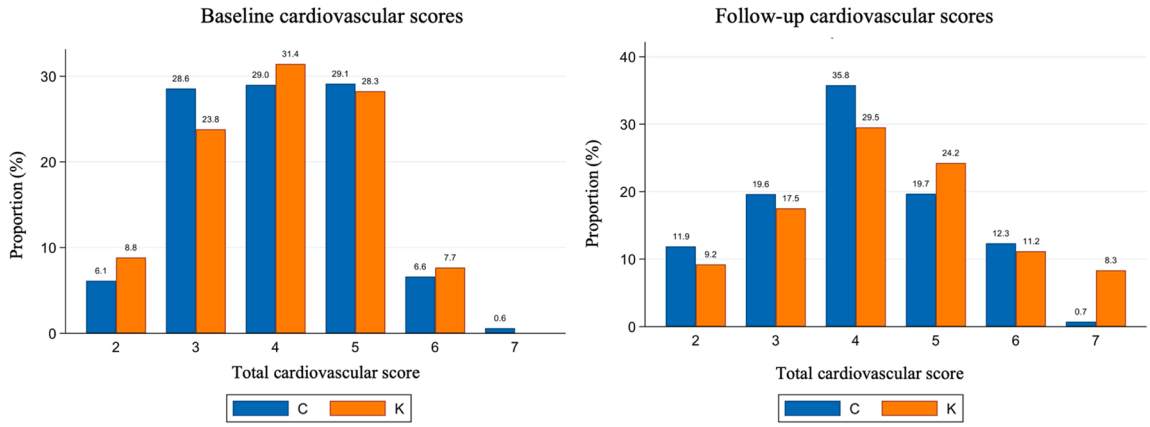

Fig. 2. The distribution of the total score of ideal cardiovascular health index by participant groups at baseline and 5-year follow-up Note. C= comparison families; K= intervention families.

Table 2
Association between Health Empowerment Programme and change in total score of ideal cardiovascular health index at 5-year follow-up after propensity score weighting.

	B (SE)	*P* value	95% CI
Demographic information			
Age	0.00 (0.01)	0.80	(−0.02, 0.01)
Gender			
Female	–	–	–
Male	-0.31 (0.14)	0.03 *	(−0.59, −0.03)
Educational level			
No higher education	–	–	–
Higher education (Tertiary/Further education)	0.44 (0.18)	0.01 *	(0.09, 0.79)
Working status			
Not working (home maker, retired, unemployment)	–	–	–
Working (employee or employer)	0.14 (0.11)	0.23	(−0.09, 0.36)
Marital status			
Unmarried (single/ widower)	–	–	–
Married	0.02 (0.15)	0.88	(−0.28, 0.32)
Monthly family income, HKD			
< 11,000	–	–	–
> =11,000	0.05 (0.12)	0.66	(−0.19, 0.29)
Government assistance reception			
No	–	–	–
Yes	-0.09 (0.17)	0.61	(−0.42, 0.25)
Chronic morbidity			
No	–	–	–
Yes	-0.16 (0.10)	0.09	(−0.35, 0.03)
Baseline ICHIs	-0.29 (0.05)	< 0.001 *	(−0.39, −0.19)
HEP	0.33 (0.09)	< 0.001 *	(0.14, 0.51)
R^2	0.12		
F value	6.04 *		

Note. * *p* value < 0.05 is statistically significant. SE = Standard error. Post-hoc power for the effects of HEP on change in total score of ideal cardiovascular health index is 0.71.

comparison group (from 85.25% to 84.27%) while it remained the same in intervention group (80.56%). Table 4 displays the results of the Poisson regression after IPTW, which shows that the HEP was associated with increased proportion of people achieving ideal blood pressure health at the 5-year follow-up (IRR: 3.39, $p < 0.05$, post-hoc power = 0.97).

Table 3
Distributions of metrics of the ideal cardiovascular health index by participant groups after propensity score weighting.

	Baseline		Follow-up	
	Intervention group	Comparison group	Intervention group	Comparison group
Health behaviors				
Smoking	*N* = 103 86 (83.46%)	*N* = 116 99 (85.56%)	*N* = 103 87(84.54%)	*N* = 116 97 (83.41%)
Body mass index	*N* = 103 42 (41.20%)	*N* = 116 45 (39.01%)	*N* = 103 43 (41.57%)	*N* = 116 34 (29.56%)
Physical activity	*N* = 103 15 (14.81%)	*N* = 116 24 (20.39%)	*N* = 103 29 (28.54%)	*N* = 116 28 (24.13%)
Diet	*N* = 103 10 (9.92%)	*N* = 116 7 (5.67%)	*N* = 103 33 (31.81%)	*N* = 116 27 (23.51%)
Health factors				
Total cholesterol	*N* = 103 103 (100.00%)	*N* = 116 116 (100.00%)	*N* = 103 103 (100.00%)	*N* = 116 116 (100.00%)
Blood pressure	*N* = 103 66 (64.33%)	*N* = 116 78 (67.44%)	*N* = 103 71 (68.60%)	*N* = 116 68 (58.28%)
Fasting glucose	*N* = 103 83 (80.56%)	*N* = 116 99 (85.25%)	*N* = 103 83 (80.56%)	*N* = 116 98 (84.27%)
Total Score (Mean ±SD)	4.02 ± 1.09	4.03 ± 1.07	4.36 ± 1.37	4.03 ± 1.20

3.4. Sensitivity analysis

Results from the sensitivity analysis of applying multiple linear regression without PS weighting and including only participants with follow-up durations longer than 24 months and 36 months, respectively, (See Supplementary Table 5–8) were consistent with main results.

4. Discussion and conclusion

This study is among the first to implement a long-term and complex HE intervention to improve cardiovascular health for adults from low-income families. The findings from our 5-year comparative cohort study have demonstrated that this HEP is effective in enhancing the cardiovascular health of adults from low-income families, with an

Table 4
Poisson regression on the effect of Health Empowerment Programme on improvement in ideal cardiovascular health index metrics at 5-year follow-up after propensity score weighting.

	IRR (Robust SE)	95% CI of IRR	95% CI of coefficient (B)	*P* value for B	Post-hoc Power
Health behaviors					
Smoking	2.19 (2.40)	(0.26, 18.70)	(−1.36, 2.93)	0.47	0.25
Body mass index	1.88 (1.09)	(0.61, 5.85)	(−0.50, 1.77)	0.27	0.34
Physical activity	1.02 (0.30)	(0.57, 1.81)	(−0.56, 0.59)	0.95	0.03
Diet	1.36 (0.35)	(0.81, 2.26)	(−0.21, 0.82)	0.24	0.41
Health factors					
Total cholesterol	–	–	–	–	
Blood pressure	3.39 (1.86)	(1.16, 9.95)	(0.15, 2.30)	0.03 *	0.97
Glucose	0.27 (0.47)	(0.01, 8.63)	(−3.69, 1.06)	0.28	0.33

Note. Participants' age, gender, diagnosed chronic diseases by a doctor, marital status, monthly household income, reception of governmental comprehensive social security assistance scheme, and their initial ICHI total score at baseline were controlled in the analysis. * p value < 0.05 is statistically significant. SE = Standard error. IRR= incidence rate ratio.

increase in the total score of ICHI and improved blood pressure status.

4.1. Discussion

Our findings demonstrate the effectiveness of our HEP in improving the total ICHI score among low-income families. This aligns with previous studies that have shown the effectiveness of HE programs on improving total ICHI score among various vulnerable populations such as adolescents [15], individuals with hypertension [16] or cardiovascular risk [18], and adults with serious mental illness [21]. These findings also confirm the effectiveness of health interventions in improving the cardiovascular health among various vulnerable populations, as reported by a systematic review of 32 studies [25]. The diverse and interconnected components of our HEP could have improved ICH in various ways: exercise courses can improve or mitigate the decline of physical capacity and cardiovascular function [43]; nutrition talks and workshops encourage a healthy diet [44]; regular health assessments facilitate timely detection and intervention on CVDs risk factors [45]. As of March 2022, 93.5% of intervention families participated in at least one health assessment program, while 55% attended at least one health enablement course or seminar. This suggesting that health assessments are the most accessible and foundational component of the HEP in this study.

However, aside from an improvement in ideal blood pressure status, the associations between HEP and changes in other individual ICHI metrics were not significant. This finding contrasts with previous studies that showed their health empowerment interventions not only improved ideal blood pressure status but also reduced BMI, increased physical activity levels, promoted healthy dieting, etc. among participants [46, 47]. This study might not have had sufficient power to detect minor changes in individual ICHI metrics. A meta-analysis [25] also concluded that cardiovascular health interventions targeting at decreasing blood pressure were the most promising and consistent in racial and ethnic minorities as well as low-income groups; in contrast, intervention targeting at improvements in other ICHI metrics, particularly behavior changes, were more challenging.

The varied impact of health interventions on ICHI metrics can be attributed to the challenge of lifestyle change. Successful lifestyle changes often involve linking intended behaviors to environmental cues or routine activities and require motivation and detailed plans for individuals to manage such behaviors [48]. Additionally, low-income workers tend to do manual labor, vulnerable to negative and stressful work experience, which can hinder their physical experiences and health eating [49]. This suggests two potential directions for future cardiovascular health interventions targeting health lifestyle behaviors. One approach involves implementing interventions at the community or societal level, such as increasing neighborhood walkability or limiting access to sugary drinks, which can create habits or built-in reminders for behavioral change. Initiatives such as bulk purchase, to make healthy food such as fruits and vegetable more available and affordable in low-income communities should be explored. Another approach is to provide courses or consultations that enable individuals establish detailed plans to achieve ideal health.

Unlike previous intervention on cardiovascular health, our study integrated resources from NGOs, health providers, and researchers, offering physical, online, and digital interactions to meet individual needs. The entire families (children, parents and grandparents) were involved, allowing knowledge, attitude and practice of healthy living being shared among family members and with peers in the same community. Therefore, we did not specifically track participants' exact engagement in our HEP. Meanwhile, our study did not explicitly control comparison group from participating in other health-related activities, respecting their freedom. Any bias from the comparison group's participation in other activities would have reduced the effect of the HEP intervention, which would not have changed the conclusion that our HEP was effective.

There are several limitations in the present study. First, selection bias might exist since individuals voluntarily enrolled in the HEP and may have had preexisting motivation to seek health-related knowledge and support compared to others. The allocation of participants into intervention or comparison groups was not randomized, potentially leading to bias in the results due to confounders. Additionally, the intervention was limited to individuals living in a specific district in Hong Kong, so the sample may not be representative, and the results may not be generalizable to other populations. Nevertheless, it is important to note that the baseline covariates between the groups were adjusted by using PS weighting before further analysis. Second, some data on ideal health behavior (i.e., smoking, physical activity, and healthy diet) were self-reported by participants, which could introduce bias from a tendency to give socially acceptable answers. However, this applied equally to both the intervention and comparison groups and for both the baseline and follow-up data. Third, the TFES families also received employment and education support in addition to the HEP, which could impact ICH through increased household income and access to health resources. Finally, although the baseline health resources between Tung Chung and Kwai Chung districts were similar, variations in health resources could have occurred as the intervention progressed. Fifth, we conducted health talks, seminars, and enablement courses. Although significant increase in participants' health knowledge following each seminar was found, we did not measure health literacy via a standardized instrument. Future studies should consider including a standardized measure of health literacy to complement these findings. Finally, we did not precisely track participants' engagement, which could reveal correlations between programme involvement and cardiovascular health improvements. Future studies should consider using digital tools to log participation in activities or conducting regular check-ins to monitor engagement.

Despite these limitations, the HEP in this study offers valuable insights. First, our approach represent HE programs' impact on cardiovascular health in real-world settings, translating previous research evidence into practice. It suggested that HE is a feasible means to escape the cycle of poverty and ill health through enhanced health literacy and self-care. Second, it was feasible to sustain a complex HE intervention, with integrated components of enhancing health literacy, encouraging regular exercise, promoting parent-child interactive activities, and providing cues for health actions, by making use of the resources in the

local community. The benefit of the HEP is the synergistic effects of the diverse yet interrelated components, the total is more than the sum of individual intervention. Third, the involvement of the whole family and the intervention in a community setting helps to sustain the adoption of a healthy lifestyle by learning from significant others and its diffusion within the community. Fourth, we initially provided a more intensive phase that was either individual or group-based, followed by a less intensive follow-up that included individual telephone support and support mobile apps. The combination of online and offline, in-person or remote interventions increase the frequency that individuals receive cues to practice health living and provides valuable references for the implementation of large-scale complex empowerment interventions in practical contexts.

4.2. Conclusion

We conducted a prospective cohort study to evaluate the impacts of our HEP on improving cardiovascular health for adults from low-income families. The ICHI defined by the American Heart Association was adapted to assess the cardiovascular health status of both the intervention group and comparison group at baseline and follow-up. After inverse propensity score weighting, we utilized multiple linear regression and Poisson regression to investigate the effectiveness of the HEP. The results indicated that our HEP was associated with a significant increase in the ICHI total score, and an increased percentage of individuals achieving normal blood pressure. The findings suggest that the HEP can serve as an effective and enduring approach to mitigate social inequalities in cardiovascular health among adults from low-income families.

4.3. Practice implications

This study demonstrates the long-term benefits of a HEP in enhancing cardiovascular health for adults from low-income families. It provides valuable insights into the practical implementation of HEP in a community setting, showing its potential to reduce social health disparities. Incorporating regular health assessments to engage these families and promote interactive activities that encourage self-care and consistent exercise can be feasible and sustainable for self-care enablement and overall well-being. This opens up a new research area to investigate how HEP care models can be more widely implemented, which may eventually lead to changes in health and social policy and services to promote better health equity for low-income families.

CRediT authorship contribution statement

Emily Tsui Yee TSE: Writing – review & editing, Supervision, Methodology, Conceptualization. **Cindy Lo Kuen Lam:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Lanlan Li:** Validation, Methodology, Formal analysis, Data curation. **Daniel Yee Tak Fong:** Writing – review & editing, Methodology, Conceptualization. **Patrick Ip:** Writing – review & editing, Methodology, Conceptualization. **Fangcao Lu:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Carlos King Ho Wong:** Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization. **Amy Pui Pui Ng:** Writing – review & editing, Methodology, Conceptualization.

Declaration of Competing Interest

During the preparation of this work the author(s) used ChatGPT in order to proofediting. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.pec.2024.108240.

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