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Effect of an Internet-Hospital-Community-Home Linked Health Management Model in Patients with Osteoporotic Vertebral Compression Fractures Who Received Conservative Treatment: A Quasi-Experimental Study

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ABSTRACT

Objective: To evaluate the effect of an internet-hospital-community-home (IHCH) linked health management model in the management of patients with osteoporotic vertebral compression fractures (OVCF) who undergoing conservative treatment.

Methods: This quasi-experimental study enrolled patients with OVCF who undergoing conservative treatment and visited to xx hospital between April 2022 and September 2022. Patients were divided into two group based on their time of visit to receive the IHCH linked health management (IHCH group) or routine management (control group). The outcomes were activities of daily living (ADL) scores, quality of life [measured by SF-36 Health Survey (SF-36) scores], functional disability [measured by Roland-Morris Disability Questionnair (RMDQ) score], pain assessment [measured by Visual Analog Scale (VAS) score] at acute stage, 1 month, 3-month, 6 months after intervention; and pressure injuries, medication adherence, and health service satisfaction at 6 months after intervention.

Results: Sixty-two patients completed the follow-up, with 31 cases in each group. The baseline information between the two groups were comparable (all P>0.05). After intervention, repeated measures ANOVA showed that the ADL ($P\ time < 0.001$, $P\ group = 0.045$, $P\ time\ x\ group < 0.001$), SF-36 ($P\ time < 0.001$, $P\ group = 0.008$, $P\ time\ x\ group < 0.001$), and RMDQ scores ($P\ time < 0.001$, $P\ group = 0.014$, $P\ time\ x\ group < 0.001$) in IHCH group were significantly improved compared to the control group, which were interacted with time. Furthermore, at the 6-month follow-up, the IHCH group exhibited significantly lower incidence of pressure injuries [2 (6.67) vs 8 (26.67), P = 0.038], higher medication adherence [16 (53.33) vs 9(30.00), P = 0.031], and greater satisfaction with health services [Total satisfaction: 27 (90.00) vs 19 (63.33), P = 0.015] compared to the control group.

Conclusion: The IHCH linked health management model might improve the effectiveness of conservative treatment for OVCF patients, reduce the occurrence of complications, and enhance satisfaction with health services.

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Introduction

With the aging population, osteoporotic vertebral compression fractures (OVCF) have become a continuously growing public health concern. OVCF leads to chronic pain, limb deformities, height

reduction, impaired daily activities, pressure injuries, pneumonia, anxiety, and depression, imposing a significant economic burden on society and families [1, 2]. Currently, several treatment methods exist, including conservative treatment, traditional surgery, and minimally invasive surgery [3]. Conservative treatment for OVCF involves extended bed rest, oral analgesics, orthopedic bracing, and the use of anti-osteoporotic medications [4]. Although relatively low-risk, conservative treatment is associated with complications related to bed rest, medication side effects, and poor tolerance of bracing, such as pressure injuries, deep vein thrombosis, and vertebral collapse [5, 6]. Currently, there is no comprehensive management model for conservatively treated OVCF patients, with the majority relying on routine management by community healthcare professionals and family members. However, due to insufficient professional expertise among community healthcare professionals and inadequate patient and family understanding of the disease, as well as suboptimal caregiving, effective recovery for patients is not guaranteed.

With the aging population, increasing prevalence of chronic diseases, and the demand for more efficient utilization of medical resources, Internet-based, mobile device-enabled remote healthcare, and a hospital-community-home-patient linked health management model have emerged [7-9]. This health management model, based on the Internet and mobile devices, aims to integrate medical resources, improve healthcare service efficiency, and facilitate comprehensive management of patients across hospital, community, and home settings [7, 10]. Leveraging information technology, this model enables patients to access more convenient and personalized medical services, simultaneously reducing healthcare costs and optimizing the allocation of medical resources [11]. In this model, hospitals serve as the focal point for medical services, utilizing the Internet and mobile devices for remote information transmission and management [12]. Communities play a crucial role in patient recovery and daily management, providing basic medical services and health education. The home, as the final line of defense in patient health management, employs smart medical devices and Internet technology for real-time monitoring and personalized health managemen [13-15].

However, despite the partial adoption and application of Internet-based health management models in China, there are still some shortcomings. Firstly, there are barriers to information sharing and interoperability, with issues related to standardization and privacy security in the transmission of medical information between different levels. Secondly, patient acceptance of new models is relatively low, and the level of community healthcare services and the popularity of smart health devices in some regions still need improvement. Additionally, the lack of comprehensive policy support and unified technical standards hinders the comprehensive development of this model. This study constructed a internet-hospital-community-home (IHCH) linked health management model and assessed its application value in the health management of patients with osteoporotic vertebral compression fractures (OVCF) who undergoing conservative treatment.

Methods

Study design and participants

This quasi-experimental study enrolled patients with OVCF who undergoing conservative treatment and visited to The First People's Hospital of Chuzhou, Anhui Province between April 2022 and September 2022. Inclusion Criteria: 1) Age $\geq$ 55 years; 2) Presence of thoracic or lumbar back pain, confirmed by MRI diagnosis as OVCF; 3) Injury occurring within the past week; 4) Adequate understanding of both minimally invasive surgical and conservative treatment options, voluntarily choosing conservative treatment; 5) Absence of neurological or spinal cord injury symptoms; 6) Patients with clear consciousness, ability to independently express their intentions, normal communication skills, and full self-care ability in daily life before the onset of the disease. Exclusion Criteria: 1) Fractures caused by other reasons, such as primary tumors, metastatic tumors, etc.; 2) Chest or back pain caused by other reasons; 3) Presence of dementia, severe cardiopulmonary diseases, malignant tumors, or conditions affecting normal limb function; 4) Non-cooperation during the follow-up process; 5) Family caregivers incapable of using smartphones. This study adheres to the principles of the Helsinki Declaration and the study protocol was approved by the Ethic Committee of The First People's Hospital of Chuzhou. All patients were fully informed, provided voluntary consent, and willingly participated in the study.

Interventions

Grouping: Patients who received treatment between April and June, 2022, were designated as the control group to receive routine management. while those between July and September, 2022 were designated as observation group to reveice IHCH linked health management.

IHCH Linked Health Management Team: To construct an IHCH linked health management team, a total of 29 members were recruited, comprising: 1) Eight individuals from a tertiary hospital, including two physicians and six nurses, all with over 10 years of clinical experience in treating and caring for OVCF patients. 2) Twenty-one community service personnel, distributed across five communities in Langya District (Nanmen, Qingliu, Yangzi, Xijian, Langya, and Xifangsi Community Health Service Centers) and two communities in Nanqiao District (Longpan and Dawang Community Health Service Centers). Each community had one physician and two nurses. Defined responsibilities for each member: The project leader was responsible for coordinating and managing team members, maintaining the WeChat public account, facilitating communication between hospitals, communities, and patients, developing various assessment scales, conducting team member training, implementing various measures, and ensuring quality control. Five nurses from the tertiary hospital and two nurses from each community were tasked with implementing the linked health management nursing services for OVCF conservative treatment patients in their respective communities. Two physicians from the tertiary hospital and one physician from each community were responsible for guiding, consulting, and quality control of patient treatment in their respective communities. Before project implementation, the project leader and a physician from the tertiary hospital provided training to all members, ensuring proficiency in health care services under the linked management model.

Establishment of an Internet Platform and WeChat Group: The team applied for a WeChat public account, featuring three modules: Health Knowledge, Assessment Scales, and Health Interaction. The project leader and third-party personnel conducted daily maintenance and management. The modules included: 1) Health Knowledge: Providing disease-related knowledge and health guidance. 2) Assessment Scales: Allowing online completion and submission of various scales, including ADL scale, SF-36 scale, Roland-Morri's scale, VAS score, Morisky medication adherence scale, and health service satisfaction survey. Relevant instructions and scoring methods were included. 3) Health Interaction: Enabling communication among medical professionals, nurses, and patients through the WeChat public account to understand patients' at-home treatment status and address any issues.

Hospital Responsibilities: 1) Analyzing the needs of patients at different age stages: Strengthening health education and functional exercise for patients aged 55-70, focusing on restoring self-care ability and social activities. For patients aged 70-80, emphasizing psychological care and anti-osteoporosis treatment to prevent recurrent fractures. Patients aged 80 and above require enhanced safety care and complication prevention, particularly pressure injuries, DVT, and mortality. 2) Analyzing the root causes of patients' underlying conditions: Observing whether patients are underweight or overweight, inquiring about habits such as picky eating, coffee consumption, lack of physical activity, and inadequate sun exposure. 3) Analyzing intervention focus for different stages: Within the first month of fracture, prioritizing basic nursing needs to prevent pressure injuries and DVT. From 1-3 months, assisting patients with getting out of bed to prevent falls and recurrent fractures. From 3-6 months, assisting and encouraging patients in lumbar and back muscle functional exercises, continuing anti-osteoporosis treatment to prevent recurrent fractures. 4) Conducting one-on-one communication with patients and their families, understanding their needs, analyzing the causes of patients' conditions, and formulating nursing plans through discussions with the linked health management team. 5) Establishing patient records, including general information, nursing plans, nursing measures, and various assessment forms. 6) Disseminating OVCF conservative treatment-related knowledge and nursing skills via the WeChat public account, hosting lectures, and training community nurses and family caregivers. Topics include pain management, pain care, daily care guidance (including bedhead washing, bed sponge bathing, deep breathing, ankle pumping exercise, axial turning, methods of equal-length and equal-tension movement of lower limb muscles), dietary guidance, rehabilitation guidance, and osteoporosis health knowledge.

Community Responsibilities: Implementing corresponding nursing measures based on the patient care plan developed by the tertiary hospital. Creating a schedule and follow-up content for home visits, adjusting them promptly based on the patient's specific situation. Monitoring patients' diet, sleep, pain, skin conditions in pressure areas, explaining the importance of timely turning, instructing patients in deep breathing, ankle pumping exercise, axial turning, and equal-length and equal-tension contraction of lower limb muscles. Assisting family caregivers in performing operations such as bedhead washing and bed sponge bathing. Providing successful case examples to boost confidence in treatment. Paying attention to the psychological activities of patients and family caregivers and providing timely guidance for any negative emotions. In case of difficulties, contacting hospital medical personnel through the WeChat platform or WeChat group for resolution. Completing various assessments and registrations according to the timeline and uploading relevant data.

Family Responsibilities: Identifying the primary caregiver in the family (spouse, children, or a hired caregiver) to implement health management for patients under the Internet-based guidance and assistance of hospital and community healthcare personnel. The main responsibilities include: 1) Preventing pressure injuries: Assisting patients with turning every 30 minutes to 2 hours, checking the skin in pressure areas, and promptly contacting medical personnel in case of abnormal skin conditions. 2) Preventing deep vein thrombosis (DVT): Daily exercises to prevent DVT based on the patient's condition, following the methods instructed by medical personnel, including deep breathing, ankle pumping exercises, equal-length and equal-tension contractions of the quadriceps, etc. 3) Administering pain relief and anti-osteoporosis medication as prescribed, observing the response to medications. 4) Assisting patients, under the guidance of healthcare personnel, in light activities with the aid of a waistband after 6-8 weeks of bed rest, progressively advancing, and simultaneously engaging in lumbar and back muscle exercises. 5) Assisting patients with basic care, providing a light and easily digestible diet.

For the control group, patients received routine management which involves bed rest for three months, pain relief medication, and anti-osteoporosis drug therapy, community nurses conducted weekly telephone follow-ups to understand medication usage and disease progression. If any issues were identified, community doctors provided guidance and adjusted the treatment plan accordingly.

Outcomes

The effect of an IHCH linked health management model were meansured by activities of daily living (ADL), quality of life, functional disability, pain at acute stage, 1 month, 3-month, 6 months after intervention; and pressure injury, medication adherence, and health service satisfaction at 6 months after intervention. ADLassessment: Assess patients' daily activity capabilities using the Barthel Index, with a total score of 100; a higher score indicates better activity capability [16]. Quality of life: Evaluate patient life quality with the SF-36 Health Survey, comprising 8 items, each scored 0-100; higher scores indicate better life quality [17,18]. Functional disability: The functional disability using the Roland-Morris Disability Questionnaire, consisting of 24 questions; a lower score indicates better lumbar function [19,20]. Pain assessment: Employ the Visual Analog Scale (VAS) for pain assessment and record patients' pain levels [21,22]. Pressure injury incidence: Calculate the incidence of pressure injuries as the number of affected patients divided by the total number of patients. Medication adherence: Assess patients' medication adherence using the Chinese version of the Morisky Medication Adherence Scale (MMAS-8), with higher scores indicating better adherence [23,24]. Health service satisfaction: Evaluate satisfaction with health services using a self-designed questionnaire; a total score ≥90 is considered "very satisfied".

In addition, the baselineinformation, including age, gender, BMI, educational level, marital status, economic income, living conditions, fracture location, and fracture segment, were collected.

Statistical Analysis

Analyze data using SPSS 26.0 (IBM Corp., Armonk, N.Y., USA). Continuous data were expressed as mean ± standard deviation (SD) and compared by repeated measures ANOVA. Categorical data were expressed as n (%), and compared by the Chi-square test. Two-sided $P<0.05$ was considered as statistical significance.

Results

Baseline Characteristics

A total of 70 eligible patients were enrolled, with 62 completing the follow-up (31 in the control group [1 patient deceased, 4 hospitalized (1 with DVT, 2 with recurrent fractures, 1 underwent midway hospitalization surgery, 1 lost to follow-up)] and 31 in the observation group (1 patient underwent midway hospitalization surgery, 1 lost to follow-up). The baseline information between the two groups were comparable (all $P>0.05$) (Table 1).

Table 1: Baseline Characteristics

Variables	Linkage group (n=30)	Control group (n=30)	t/χ^2	*P value*
Age, years, mean ±SD	70.19±9.55	70.16±8.68	-0.013	0.990
Sex, n (%)			0.111	0.740
Male	6 (19.35)	5 (16.13)		
Female	25 (80.65)	26 (83.87)		
BMI, Kg/m^2, mean ±SD	23.89±2.81	23.88±3.00	-0.014	0.989
Education, n (%)			-0.621	0.535
Primary School or Below	17 (54.84)	20 (64.52)		
Junior and senior high schools	13 (41.93)	9 (29.03)		
Junior college or above	1 (3.23)	2 (6.45)		
Marital status, n (%)			0.161	0.688
Married	27 (87.10)	28 (90.32)		
Unmarried	0 (00.00)	0 (00.00)		
Divorced or widowed	4 (12.90)	3 (9.68)		
Monthly income, n (%), Yuan			-0.604	0.546
<2,000	23 (74.19)	21 (67.74)		
2,000-5,000	7 (22.58)	8 (25.81)		
>5,000	1 (3.23)	2 (6.45)		
Housing condition, n (%)			0.738	0.3905
With separate room	29 (93.55)	27 (87.10)		
Without separate room	2 (6.45)	4 (12.90)		
Fracture site, n (%)			1.000	0.317
Thoracic vertebra	15(34.88)	21 (51.22)		
Lumbar segment	28(65.12)	20 (48.78)		
Fracture segment, n (%)			1.341	0.720
Single segment	22 (70.96)	21 (67.74)		
2-segment	7 (22.58)	7 (22.58)		
3-segment	1 (3.23)	2 (6.45)		
4-segment	1 (3.23)	0 (0.00)		

Outcomes

Repeated measures ANOVA showed that, compared with the control group, the ADL (*P time* < 0.001, *P group* = 0.045, *P time* x group < 0.001), SF-36 (*P time* < 0.001, *P group* = 0.008, *P time x group* < 0.001), and Roland-Morris scores (*P time* < 0.001, *P group* = 0.014, *P time x group* < 0.001) were significantly improved in IHCH group, which were interacted with time (Tables 2). Furthermore, at the 6-month follow-up, the IHCH group exhibited significantly lower incidence of pressure injuries [2 (6.67) vs 8 (26.67), *P* = 0.038], higher medication adherence [16 (53.33) vs 9(30.00), *P* = 0.031], and greater satisfaction with health services [Total satisfaction: 27 (90.00) vs 19 (63.33), *P* = 0.015] compared to the control group (Table 3).

Table 2: Repeated Measures ANOVA for Barthel, SF-36, Roland-Morris, and VAS Score

Outcomes	Linkage group (n=30)	Control group (n=30)	*F time/F group/F time x group*	*P time/P group/P time x group*
Barthel score, mean ±SD			3209.128/2.886/6.345	<0.001/0.045/<0.001
Acute stage	45.48±4.15	46.45±14.96		
1 month	52.90±4.61	50.97±4.55		
3 month	81.61±3.96	78.55±5.66		
6 month	92.90±6.02	89.68±5.62		
SF-36score, mean ±SD			4076.60/7.619/20.348	<0.001/0.008/<0.001
Acute stage	246.74±85.57	253.77±98.27		
1 month	323.18±84.93	357.61±85.52		
3 month	565.90±81.52	506.59±88.92		
6 month	668.79±77.66	612.25±75.02		
Roland-Morrisscore, mean ±SD			1238.400/6.394/19.036	<0.001/0.014/<0.001
Acute stage	20.29±2.34	20.00±2.41		
1 month	17.97±1.87	18.45±1.86		
3 month	12.10±1.90	14.03±2.54		
6 month	6.58±1.63	9.29±2.55		
VASscore, mean ±SD			1257.069/3.446/3.947	<0.001/0.048/0.009
Acute stage	5.46±0.83	5.35±0.82		
1 month	2.68±0.50	3.07±0.54		
3 month	1.09±0.71	1.49±0.76		
6 month	0.43±0.45	0.72±0.58		

Table 3: Comparison of Pressure Injury, Medication Adherence, amd Health Service Satisfaction

	Linkage group (n=30)	Control group (n=30)	χ^2	P
Pressure injury,n (%)	2 (6.67)	8 (26.67)	4.320	0.038
Total health service satisfaction	27 (90.00)	19 (63.33)	5.963	0.015
Degree of health service satisfaction			-2.218	0.027
Unsatisfaction	3 (10.00)	11 (36.67)		
Moderate	15 (50.00)	12 (40.00)		
Very satisfied	12 (40.00)	7 (23.33)		
Medication adherence			-2.154	0.031
Poor	5 (16.67)	12 (40.00)		
Moderate	9 (30.00)	9 (30.00)		
Good	16 (53.33)	9 (30.00)		

Discussion

This study highlights that the IHCH linked health management model might improve the effectiveness of conservative treatment for OVCF patients, reduce the occurrence of complications, and enhance satisfaction with health services. These findings provide clinical data support for the application and promotion of the IHCH linked health management model, offering new avenues for improving the prognosis and quality of life of OVCF patients undergoing conservative treatment.

In this study, the implementation of IHCH linked health management for conservatively treated OVCF patients resulted in significantly superior ADL, SF-36, Roland-Morris scores at 3 and 6 months, as well as lower pain scores at 1, 3, and 6 months compared to the control group. This suggests that IHCH linked health management enhances the effectiveness of conservative treatment. The decentralization of high-quality medical resources from tertiary hospitals to the community, coupled with the training of community health professionals in OVCF-related knowledge and care skills, played a pivotal role. They guided and supervised family members in providing home care and rehabilitation exercises for patients, ensuring personalized, continuous care. This approach facilitated timely consultation with tertiary hospital professionals in case of worsening conditions or complications, maximizing the effectiveness of conservative treatment. Consistent with our study, similar effective applications of the IHCH linked health management model were reported in diseases such as stroke, hypertension, diabetic foot, preterm birth and peptic ulcer management [10,15,25-27].

The main characteristics of patients with OVCF are pain and limited self-care ability, conservative treatment requires patients to stay in bed for a long time, improper care is prone to stress injury and DVT, and is more prone to re-fracture, which seriously affects patients' physical health and quality of life, and even leads to death, causing heavy economic burden and care pressure for patients' families [28, 29]. Most of the nursing care of conservative treatment patients is completed by family members. Due to the lack of disease-related knowledge and nursing skills, it is easy to lead to related complications of patients. This study demonstrated that IHCH linked health management significantly reduced the incidence of pressure injuries in the observation group, with no occurrences of DVT and recurrent fractures at the 6-month follow-up. This reduction in complications is attributed to leveraging the technical expertise of tertiary hospitals, training community health professionals, utilizing the accessibility of community services, providing home visits, monitoring health status, and offering continuous guidance and support through the WeChat platform This approach empowered patients with professional treatment and care guidance at home, improving confidence, reducing symptoms, minimizing complications, and enhancing overall life quality [30, 31].

The IHCH linked health management model provides continuous, cost-effective, convenient, and efficient medical services for patients. It ensures timely and effective responses to any health issues through the WeChat platform or telephone [10]. This study demonstrated that implementing IHCH linked health management for conservatively treated OVCF patients significantly improved patient satisfaction and medication adherence compared to the control group. The model, based on internet support, strengthened the connection between patients, specialized medical teams from tertiary hospitals, and community health professionals. It met the needs of patients for home-based treatment, effectively implemented the radiative effects of tertiary hospitals in providing high-quality nursing resources, and enhanced the nursing service capability of community health service centers [10, 15, 32, 33]. This led to tangible benefits for patients, gaining recognition from patients, communities, and society, ultimately increasing satisfaction.

This study is not without limitations. In comparison with randomized controlled trials, this study lacks the advantage of random allocation, grouping patients based on their time of visit, which may introduce selection bias or historical bias. This potential baseline difference at the study's initiation could complicate the interpretation of causal relationships, limiting generalizability. Additionally, the small sample size may require further confirmation through larger studies for the reliability of conclusions. Nevertheless, this study still provides clinical evidence for the application and promotion of the IHCH linked health management model.

In conclusion, the IHCH linked health management model improves the outcomes of conservatively treated OVCF patients, reducing complications and increasing satisfaction with health services. However, further multicenter studies with larger sample sizes are needed to validate these findings.

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None.

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

Competing Interests
All the authors declare that they have no conflict of interest.

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Author's Contributions
Tingye Hu, Gan Zhang and Huiru Wang carried out the studies, participated in collecting data, and drafted the manuscript. Xiuping Hu and Hong Ye performed the statistical analysis and participated in its design. Chengling An and Ping Huang participated in acquisition, analysis, or interpretation of data and draft the manuscript. All authors read and approved the final manuscript.

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