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ORIGINAL RESEARCH

Integrated Internet-Based Pharmaceutical Care and Its Association with Clinical Outcomes and Medication Adherence in Older Adults with Multimorbidity: A Prospective Observational Study

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Objective: To compare clinical outcomes, quality of life (QoL), medication behaviors, and readmission risk between older adults with multimorbidity receiving integrated Internet-based pharmaceutical care and those receiving conventional pharmaceutical care.

Methods: This prospective observational study enrolled 196 older adults with multimorbidity who received either conventional or integrated Internet-based pharmaceutical care according to the service model in routine practice. After 6 months, BG and BP control rates, hospitalization rates, and patient satisfaction were compared. Frailty, health-related quality of life, medication self-management, and adherence were assessed using the FRAIL scale, EQ-5D/EQ-VAS, SEAMS, and ARMS-12, respectively. Logistic regression was used to examine the association between care model and 12-month readmission.

Results: At the 6-month follow-up, the integrated Internet-based pharmaceutical care group had significantly higher BG and BP control rates and patient satisfaction than the conventional care group ($P < 0.05$). The integrated Internet-based care group also had lower FRAIL scores and higher EQ-5D and EQ-VAS scores. SEAMS scores were significantly higher, and ARMS scores were significantly lower in the Internet-based care group ($P < 0.001$). The integrated Internet-based pharmaceutical care model was significantly associated with a lower risk of 12-month readmission (OR = 0.424, 95% CI: 0.203–0.884, P = 0.022).

Conclusion: Integrated Internet-based pharmaceutical care was associated with favorable medication-related and clinical outcomes in older adults with multimorbidity. Further studies are needed to confirm these findings and clarify their generalizability.

Keywords: older adults, multimorbidity, integrated Internet-based pharmaceutical care, readmission, medication adherence, medication self-management

Introduction

The accelerating global aging population has led to a rising prevalence of multimorbidity, the coexistence of multiple chronic conditions, which has become a major public health issue impacting health outcomes and quality of life (QoL) in older adults.[1,2] Multimorbidity often necessitates long-term, complex medication regimens, increasing the risk of adverse effects and complicating disease management. Inadequate medication adherence behaviors and limited capacity for

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medication self-management are recognized as key modifiable behavioral factors influencing chronic disease control and clinical outcomes.[3] Among older adults, these challenges are exacerbated by cognitive decline, limited health literacy, and restricted access to information, leading to greater difficulties in medication management and subsequently increasing the risk of unplanned hospitalizations and healthcare resource utilization.[4]

Traditional pharmaceutical care models, in which pharmacists' roles are often limited to medication counseling and dispensing, lack continuous follow-up and dynamic management mechanisms and may not adequately meet the needs of older adults with multimorbidity for personalized and long-term support. Deficits in medication self-management capacity and complex drug regimens may make older patients more vulnerable to poor medication adherence and unstable disease control during treatment, as adherence behaviors are influenced by multiple factors including self-management ability, regimen complexity, and ongoing professional support.[5,6] Therefore, exploring informatized, continuous, and integrated pharmaceutical care models holds significant practical importance.

In recent years, driven by the development of digital health services, integrated Internet-based pharmaceutical care has gradually been introduced into chronic disease management. Such services may include online consultations, medication reminders, and remote follow-up. Existing studies suggest that digital health services may be beneficial for improving medication behaviors and health management in patients with chronic diseases.[7,8] However, comprehensive evaluations of integrated Internet-based pharmaceutical care models specifically targeting older adults with multimorbidity in real-world healthcare settings remain relatively limited. Systematic analyses of its impact on adherence-related behaviors, self-management capabilities, and clinical control indicators are particularly sparse.[9]

Furthermore, hospital readmission is considered a critical healthcare utilization indicator in chronic disease management. Older adults with multimorbidity, due to their higher disease burden and complex pharmacotherapy, are more prone to disease fluctuations and acute exacerbations, leading to rehospitalization. Prior research suggests that optimizing pharmaceutical management and enhancing continuous follow-up may contribute to reduced healthcare resource use and readmission risk.[10] Nevertheless, systematic observational data on the potential impact of integrated Internet-based pharmaceutical care models on readmission risk in real-world settings are lacking.

Consequently, this prospective cohort study was conducted in a real-world clinical environment to compare integrated Internet-based pharmaceutical care with conventional pharmaceutical care in older adults with multimorbidity. The selected outcomes, including medication adherence, medication self-management, frailty, blood pressure and blood glucose control, and health-related quality of life, were chosen because they are clinically relevant to disease control, functional status, and patient-centered outcomes in this population. In addition, 12-month readmission was evaluated as an important healthcare utilization outcome. This study aimed to evaluate the association of integrated Internet-based pharmaceutical care with medication-related and clinical outcomes in older adults with multimorbidity.

Materials and Methods

Study Participants

This prospective observational study was conducted at our hospital from March 2023 to August 2024. During the study period, the hospital progressively implemented an integrated Internet-based pharmaceutical care model alongside conventional services. Patients, during outpatient visits or hospitalizations, chose their respective pharmaceutical management mode based on service availability and personal preference, without any intervention or allocation by the researchers. Older adults with multimorbidity who met the inclusion criteria were consecutively enrolled and categorized into the conventional pharmaceutical care group or the integrated Internet-based pharmaceutical care group according to the actual service they received. All enrolled patients completed a baseline assessment at enrollment and underwent follow-up evaluations using scales and clinical indicators at the prespecified 6-month follow-up. A predefined assessment window of ±30 days around the 6-month visit was allowed. Follow-up assessments were conducted during scheduled outpatient visits, with supplementary telephone contact when necessary. Questionnaire responses were reviewed by the investigators at the time of collection, and incomplete items were checked and completed during the same encounter whenever possible. Only participants with complete follow-up data were included in the final analysis. Additionally,

readmission status within 12 months from enrollment was tracked using the hospital information system and telephone follow-ups.

Inclusion criteria were: (1) age ≥ 60 years; (2) confirmed diagnosis of hypertension and diabetes multimorbidity; (3) regular medication use for > 3 months; (4) clear consciousness and ability to cooperate with questionnaire surveys; (5) provision of signed informed consent. Exclusion criteria were: (1) presence of severe organic diseases (eg, advanced malignancies, end-stage heart or renal failure) or life expectancy < 6 months; (2) significant cognitive impairment or inability to complete questionnaires; (3) concurrent participation in other clinical studies affecting medication management; (4) significant missing data during follow-up.

Based on preliminary pilot data and previous literature, a moderate effect size difference (Cohen's d ≈ 0.5) in adherence-related behaviors was anticipated between the two groups. With α=0.05 and power of 80%, a minimum of 90 participants per group was required. The final enrollment of 196 participants met this requirement, with 98 in the conventional pharmaceutical care group and 98 in the integrated Internet-based pharmaceutical care group. This study was approved by the hospital ethics committee and conducted in accordance with the principles of the Declaration of Helsinki.

Service Models

Both groups were followed up for 6 months, with outpatient re-evaluations scheduled every 2 months to record blood glucose (BG) and blood pressure (BP) control, as well as hospitalization information during the follow-up period. In this real-world clinical setting, the service components of the two care models were implemented according to routine practice. However, detailed quantitative indicators of intervention intensity, such as the exact frequency and duration of pharmacist–patient interactions, number of reminders, consultations, and medication reviews, were not systematically recorded for all participants.

Conventional Pharmaceutical Care Model

The conventional pharmaceutical care group received standard outpatient pharmaceutical management routinely operational in the hospital. This model primarily included:

(1) Outpatient medication counseling: Following physician consultation, pharmacists provided medication education, focusing on dosage, administration timing, potential adverse reactions, and precautions.

(2) Collaborative and independent pharmacist-led clinics: Weekly physician-pharmacist collaborative clinics and independent pharmacist-led clinics were available for prescription review and medication optimization recommendations for patients on long-term chronic disease medications.

(3) Information system support: Leveraging electronic medical records and pharmacy information systems, pharmacists could access patients' medical history, medication records, and laboratory results to conduct prescription reviews and monitor medication risks.

(4) Basic follow-up and consultation: Routine inquiries and health education services were provided through outpatient return visits and online platforms.

Integrated Internet-Based Pharmaceutical Care Model

The integrated Internet-based pharmaceutical care group received management that integrated online and offline approaches, building upon conventional services and leveraging an information platform. This model enhanced information support and continuous follow-up management, providing integrated services. Its key components included:

(1) Electronic health record management: Establishing electronic medication records for patients, integrating baseline information, medical records, and long-term medication plans to facilitate continuous management.

(2) Online consultations and E-prescriptions: Patients with chronic conditions could access online consultations and follow-ups via the Internet-based hospital platform. Physicians issued E-prescriptions, and pharmacists conducted online prescription reviews.

(3) Pharmaceutical care platform support: Utilizing a pharmaceutical care platform for prescription evaluation, medication risk alerts, and medication dispensing management, ensuring digital linkage of prescription review, dispensing, and delivery processes.

(4) Intelligent reminders and remote follow-up: Employing mobile tools to provide medication reminders, push medication information, and facilitate follow-up feedback, enhancing patients' sustained management capacity for long-term medication regimens.

(5) Operational quality management: Conducting regular internal evaluations and process optimization to improve service continuity and accessibility.

Outcome Measures

The FRAIL scale, EQ-5D/EQ-VAS, SEAMS, and ARMS-12 used in this study are widely applied instruments, and relevant evidence has supported their reliability, validity, or applicability in Chinese populations, including older adults and patients with chronic diseases.[11–14]

(1) Comparison of clinical outcomes: Rates of BG control, BP control, hospitalization, and patient satisfaction were compared between the two groups over the 6-month follow-up. BG control criteria were based on relevant guidelines: fasting BG 3.9–6.1 mmol/L, 2-hour postprandial BG < 7.8 mmol/L; control rate = (number achieving control/total number) × 100%. BP control was defined as systolic BP < 140 mmHg and diastolic BP < 90 mmHg; control rate = (number achieving control/total number) × 100%. Hospitalization rate = (number hospitalized during follow-up/total number) × 100%. Satisfaction was assessed using a 5-point Likert scale, with an average score ≥ 4 defined as satisfied.

(2) Comparison of frailty status: Frailty status after the intervention was compared using the FRAIL (Fatigue, Resistance, Ambulation, Illnesses, Loss of Weight) scale,[15] proposed by the International Academy on Nutrition and Aging. This scale comprises 5 items, with a total score ranging from 0 to 5. Higher scores indicate greater frailty, and a score ≥ 3 defines frailty.

(3) Comparison of QoL: Health-related QoL was assessed using the EuroQol five-dimensional (EQ-5D) descriptive system[16] and the EQ Visual Analogue Scale (EQ-VAS).[17] The EQ-5D covers five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The EQ-VAS score ranges from 0 to 100, with higher scores indicating better self-rated health.

(4) Comparison of medication self-management and adherence behaviors: a) Medication self-management ability: Assessed using the Self-Efficacy for Appropriate Medication Use Scale (SEAMS).[18] This 13-item scale uses a 3-point Likert scoring system, with a total score ranging from 13 to 39. Higher scores indicate stronger patient self-efficacy in medication management. b) Medication adherence behavior: Evaluated using the Adherence to Refills and Medications Scale-12 (ARMS-12).[19] This 12-item scale uses a 4-point scoring system, with total scores ranging from 12 to 48. Lower scores indicate better adherence.

(5) 12-month readmission rate: Starting from the date of enrollment, the occurrence of any readmission (≥ 1 time) within 12 months was recorded. Readmission was defined as re-hospitalization for any reason. The 12-month readmission rate was calculated as (number of patients readmitted within 12 months/total number) × 100%. Questionnaire-based outcomes and clinical control indicators were assessed at the prespecified 6-month follow-up to evaluate mid-term management effects, whereas 12-month readmission was analyzed separately as a cumulative healthcare utilization outcome requiring a longer observation period.

Statistical Analysis

Data were analyzed using SPSS 26.0. The normality of continuous variables was assessed using the Shapiro–Wilk test. Normally distributed continuous variables were expressed as mean ± standard deviation and compared using the independent-samples *t* test; within-group comparisons between baseline and 6-month follow-up were performed using the paired *t* test. Non-normally distributed variables were presented as median (interquartile range) and compared using the Mann–Whitney *U*-test. Categorical variables were presented as number (percentage) and compared using the χ^2-test or Fisher's exact test, as appropriate. To examine the association between care model and 12-month readmission, univariate logistic regression analyses were performed for service model, age, sex, BMI, baseline FRAIL score, baseline

SEAMS score, and baseline ARMS score. Given the limited number of readmission events and the lack of significant covariates, the regression analysis was not further expanded into a multivariable model to avoid model instability and overfitting. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported. All tests were two-sided, and $P < 0.05$ was considered statistically significant.

Results

Baseline Characteristics Analysis

No statistically significant differences were observed between the two groups at baseline regarding age, sex, BMI, educational level, BG control status, or BP control status (all $P > 0.05$; Table 1).

Comparison of BP and BG Control Rates, Hospitalization Rates, and Satisfaction Rates

The integrated Internet-based pharmaceutical care group demonstrated significantly higher rates of BG control and BP control compared to the conventional pharmaceutical care group ($P < 0.05$). Patient satisfaction was also significantly higher in the Internet-based group ($P < 0.05$). The hospitalization rate was lower in the Internet-based group, but this difference did not reach statistical significance ($P > 0.05$) (Table 2).

Comparison of Frailty Status

At baseline, there was no significant difference in FRAIL scores between the two groups ($P > 0.05$). After the 6-month follow-up, the integrated Internet-based pharmaceutical care group had significantly lower FRAIL scores compared to the conventional care group ($P < 0.05$) (Table 3).

Table 1 Comparison of Baseline Characteristics Between the Two Groups

Characteristic	Conventional Care Group (n = 98)	Internet-based Care Group (n = 98)	t/x^2	*P*
Age (years)	70.55 ± 6.61	72.34 ± 7.92	−1.714	0.088
Sex (n, %)			0.082	0.775
Male	50 (51%)	52 (53%)		
Female	48 (49%)	46 (47%)		
BMI (kg/m^2)	26.56 ± 3.51	26.36 ± 2.82	0.449	0.654
Educational level (n, %)			0.201	0.904
Primary school or below	24 (24%)	22 (22%)		
Middle/high school	45 (46%)	48 (49%)		
College or above	29 (30%)	28 (29%)		
BG controlled (n, %)	32 (32.7%)	30 (30.6%)	0.096	0.757
BP controlled (n, %)	41 (41.8%)	43 (43.9%)	0.083	0.773

Abbreviations: BMI, Body mass index; BG, blood glucose; BP, blood pressure.

Table 2 Comparison of BP and BG Rates, Hospitalization Rates, and Satisfaction Rates

Group	n	BG Control Rate (%)	BP Control Rate (%)	Hospitalization Rate (%)	Patient Satisfaction Rate (%)
Conventional care group	98	52 (53%)	55 (56%)	22 (22%)	78 (80%)
Internet-based care group	98	69 (70%)	72 (73%)	16 (16%)	89 (91%)
x^2		6.242	6.464	1.175	4.897
P		0.012	0.011	0.278	0.027

Abbreviations: BG, Blood glucose; BP, Blood pressure.

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Table 3 Comparison of FRAIL Scores Between the Two Groups

Group	n	Baseline	After 6-Month Follow-up
Conventional care group	98	4.13 ± 0.87	3.30 ± 1.03*
Internet-based care group	98	3.96 ± 0.98	2.41 ± 1.17*
t		1.308	5.633
P		0.192	< 0.001

Note: Compared with baseline, *$P < 0.05$.
Abbreviations: FRAIL, Fatigue, Resistance, Ambulation, Illnesses, Loss of Weight.

Comparison of QoL

At baseline, no significant differences were found in EQ-5D or EQ-VAS scores between the two groups ($P > 0.05$). At the 6-month follow-up, the integrated Internet-based pharmaceutical care group exhibited significantly higher EQ-5D and EQ-VAS scores than the conventional care group ($P < 0.05$) (Table 4).

Comparison of Medication Self-Management Ability and Adherence Behaviors

At baseline, there were no statistically significant differences in SEAMS or ARMS scores between the conventional care group and the integrated Internet-based pharmaceutical care group ($P > 0.05$). At the 6-month follow-up, the SEAMS score was significantly higher, and the ARMS score was significantly lower in the Internet-based care group compared to the conventional care group ($P < 0.05$) (Table 5).

Regression Analysis of Integrated Internet-Based Pharmaceutical Care Model and 12-Month Readmission Risk

During the 12-month follow-up period, 28 patients (28.57%) in the conventional pharmaceutical care group and 14 patients (14.29%) in the integrated Internet-based pharmaceutical care group experienced readmission. In univariate logistic regression analysis, the integrated Internet-based pharmaceutical care model was significantly associated with

Table 4 Comparison of QoL Scores Between the Two Groups

Group	n	EQ-5D score		EQ-VAS Score	
		Baseline	6-Month Follow-Up	Baseline	6-Month Follow-Up
Conventional care group	98	0.74 ± 0.13	0.82 ± 0.09*	59.37 ± 8.27	62.52 ± 7.10*
Internet-based care group	98	0.72 ± 0.09	0.86 ± 0.07*	60.27 ± 8.46	70.87 ± 6.37*
t		1.506	−4.169	−0.752	−8.663
P		0.134	< 0.001	0.453	< 0.001

Note: Compared with baseline, *$P < 0.05$.
Abbreviations: EQ-5D, EuroQol five-dimensional; EQ-VAS, EuroQol Visual Analogue Scale.

Table 5 Comparison of SEAMS and ARMS Scores Between the Two Groups

Group	n	SEAMS Score		ARMS Score	
		Baseline	6-Month Follow-Up	Baseline	6-Month Follow-Up
Conventional care group	98	26.91 ± 3.82	28.24 ± 3.94*	29.58 ± 4.21	28.47 ± 4.36*
Internet-based care group	98	27.08 ± 3.89	31.93 ± 3.07*	29.41 ± 4.32	23.58 ± 3.81*
t		0.312	−7.865	0.284	8.947
P		0.756	< 0.001	0.777	< 0.001

Note: Compared with baseline, *$P < 0.05$.
Abbreviations: SEAMS, Self-Efficacy for Appropriate Medication Use Scale; ARMS, Adherence to Refills and Medications Scale.

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Table 6 Univariate Logistic Regression Analysis for 12-Month Readmission

Variable	OR	95% CI	*P*
Service model (Internet vs conventional)	0.424	0.203–0.884	0.022
Age	0.984	0.932–1.039	0.563
Sex	0.622	0.307–1.261	0.188
BMI	0.997	0.885–1.124	0.964
Baseline FRAIL score	0.936	0.594–1.477	0.777
Baseline SEAMS score	1.035	0.940–1.140	0.479
Baseline ARMS score	1.024	0.933–1.122	0.621

Abbreviations: BMI, Body mass index; FRAIL, Fatigue, Resistance, Ambulation, Illnesses, Loss of Weight; SEAMS, Self-Efficacy for Appropriate Medication Use Scale; ARMS, Adherence to Refills and Medications Scale; OR, Odds ratio; CI, Confidence interval.

a lower risk of 12-month readmission (OR = 0.424, 95% CI: 0.203–0.884, P = 0.022). Age, sex, BMI, baseline FRAIL score, baseline SEAMS score, and baseline ARMS score were not significantly associated with readmission (all P > 0.05) (Table 6). Given the limited number of readmission events and the lack of significant covariates, a multivariable model was not further expanded. Therefore, these findings should be interpreted with caution.

Discussion

In the context of multimorbidity, older patients often contend with multiple chronic conditions simultaneously, making their therapeutic management more complex due to long-term polypharmacy. As the number of medications increases and treatment duration extends, diminished medication adherence and insufficient medication management capacity emerge as critical factors affecting disease control. Traditional pharmaceutical care has limitations in terms of frequency, sustained support, and personalized management. In contrast, the integrated Internet-based pharmaceutical care model leverages digital platforms and information technology to enhance service continuity and accessibility. Based on a real-world clinical setting, this study compared the two pharmaceutical care models over a 6-month follow-up period. The results indicate that the integrated Internet-based pharmaceutical care group exhibited more favorable trends in clinical indicators, QoL, and medication behaviors.

This study observed higher rates of BG and BP control at the 6-month follow-up in the integrated Internet-based pharmaceutical care group compared to the conventional care group. This finding suggests that a pharmaceutical care model supported by digital platforms may contribute to better control of chronic disease indicators. The underlying reasons may be related to online prescription management, medication reminders, continuous follow-up, and convenient medication delivery, which could mitigate adverse effects from medication interruptions or incorrect use. Previous research has indicated that remote pharmaceutical services and pharmacist-involved multi-modal chronic disease management can improve patients' self-efficacy and disease control levels,[20–22] which aligns with the trends observed in this study. Furthermore, patient satisfaction was higher in the integrated Internet-based pharmaceutical care group, consistent with studies reporting enhanced patient experience through Internet pharmacy services.[23] However, satisfaction is a subjective outcome and may have been influenced by participants' awareness of receiving a more integrated care model in this open-label setting. Enhanced service accessibility and continuity may increase patient engagement and willingness to adhere to treatment plans. It is important to note that this study's observational design reflects associations between service models and outcomes rather than strict causal inference.

Existing literature links frailty in older adults to polypharmacy and adverse drug reactions.[24,25] In this study, the integrated Internet-based pharmaceutical care group had lower FRAIL scores at the 6-month follow-up, suggesting that this model might be associated with some degree of frailty improvement. Potential mechanisms may include more structured medication management that improves medication appropriateness and reduces the risk of adverse drug events; in addition, continuous health education and follow-up support may promote improvements in nutrition, physical activity, and lifestyle, thereby indirectly affecting functional status. Although this study did not directly assess

improvements in medication regimen optimization, the results provide clues for further exploration of the relationship between pharmaceutical care and functional status in older adults.

QoL is a crucial endpoint in chronic disease management. This study demonstrated that the integrated Internet-based pharmaceutical care group had higher EQ-5D and EQ-VAS scores compared to the conventional care group. The digital service model, through integrated online and offline approaches, enhances service continuity and information transparency, potentially bolstering patients' sense of health control. Prior studies have suggested that digital health interventions can improve patients' subjective health evaluations and well-being.[26,27] The findings of this study are consistent with this trend, indicating that the integrated Internet-based pharmaceutical care model may be associated with better patient-perceived health status.

This study revealed significantly higher SEAMS scores and lower ARMS scores in the integrated Internet-based pharmaceutical care group. SEAMS reflects patients' self-efficacy in complex medication situations, while ARMS reflects actual medication adherence behaviors. These findings suggest that the integrated Internet-based pharmaceutical care model may be associated with better medication self-efficacy and adherence behaviors, possibly through continuous education, personalized reminders, and more timely follow-up support.[28,29] Observing similar trends in a real-world setting further underscores the potential role of digital platforms in the transformation of pharmaceutical services. Compared with traditional models, integrated Internet-based pharmaceutical care strengthens feedback mechanisms and follow-up continuity, shifting pharmaceutical care from single-session guidance to continuous management.

This study further analyzed 12-month readmission and found that the integrated Internet-based pharmaceutical care model was significantly associated with reduced readmission risk. Readmission often reflects unstable chronic disease control, inappropriate medication use, or exacerbated complications, making it a critical hard outcome indicator in chronic disease management. Digital pharmaceutical care, by intensifying follow-up frequency, optimizing prescription management processes, and improving access to medication information, may potentially reduce rehospitalizations stemming from medication issues or disease fluctuations. Previous studies have shown that pharmacist-involved chronic disease management can lower healthcare utilization and the risk of acute exacerbations. The results of this study align with these trends.[30] However, given the observational design, residual confounding factors cannot be entirely excluded. Larger sample sizes and multi-center studies are needed for further validation. It should also be noted that all-cause readmission is a nonspecific endpoint and may be influenced by events not directly related to medication management or chronic disease control. Therefore, the observed association between care model and readmission should be interpreted with caution.

This study has several limitations. First, although this was a prospective observational study conducted in a real-world setting, the choice of pharmaceutical care model was not randomized and was influenced by service availability and patient preference. Therefore, selection bias and residual confounding cannot be excluded. Patients who received integrated Internet-based pharmaceutical care may have differed from those receiving conventional care in unmeasured characteristics, such as health literacy, digital engagement, family support, and motivation for self-management, which may have independently influenced the observed outcomes. Second, this was a single-center study, which may limit the generalizability of the findings to other regions or healthcare systems. Third, most scales and clinical indicators were assessed over a 6-month period, which may be insufficient to capture longer-term effects on chronic disease control and functional outcomes. Although readmission was tracked for 12 months, all-cause readmission is a nonspecific endpoint and may be influenced by factors not directly related to medication management. Moreover, the readmission analysis was based on a relatively small number of events, which may have reduced the stability of the regression estimates. Fourth, patient satisfaction is an inherently subjective outcome and may have been affected by detection bias in this open-label, non-blinded study, as participants who were aware of receiving a more integrated care model may have been more likely to report higher satisfaction. Fifth, quantitative metrics reflecting intervention intensity were not systematically available, which limited a more detailed comparison of the exposure intensity between the two care models. In addition, some potentially relevant baseline variables, such as comorbidity burden and the number of medications, were not systematically collected, which may have limited a more comprehensive characterization of the study population and adjustment for potential confounding. Other healthcare utilization outcomes, such as emergency department visits or physician visits, were also not assessed in the present study. Finally, although relevant evidence supports the use of FRAIL, EQ-5D/EQ-

VAS, SEAMS, and ARMS in Chinese populations, these instruments were not specifically validated in Chinese older adults with multimorbidity in the present study, which may still affect the interpretability of the related findings. Therefore, the findings should be interpreted as associative rather than causal, and further multicenter studies with longer follow-up are needed.

Conclusion

In this prospective observational study, integrated Internet-based pharmaceutical care was associated with more favorable medication-related and clinical outcomes in older adults with multimorbidity. Further multicenter studies are needed to validate these findings.

Human Ethics and Consent to Participate Declarations

This study was approved by the Human Ethics Committee of Hengyang Central Hospital (Approval Number: 2025-12). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Data Sharing Statement

The data used and/or analyzed during the current study are available from the corresponding author, Jie Yang.

Consent for Publication

All participants/patients provided written informed consent for the publication of their personal and clinical details, including any identifying images, as part of this study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

Jianying Zhao and Ping Liu are co-first authors for this study. The authors declare no conflicts of interest in this work.

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