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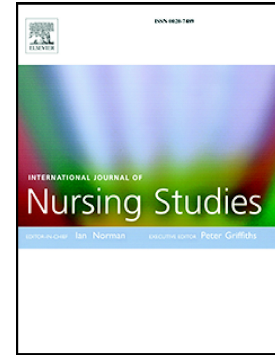
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Complex determinants of hospital discharge readiness among patients with acute myocardial infarction: a fuzzy-set qualitative comparative analysis

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Authorship contribution statement

Dandan Chen: Conceptualization, methodology, formal analysis, software, visualization, writing-original draft, writing-review & editing. **Xu Li:** Investigation, writing-review & editing. **Geraldine Lee:** Writing-review and editing. **Xiyi Wang:**

Conceptualization, supervision, project administration, validation, supervision, data curation, validation, visualization, funding acquisition, writing - review & editing.

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Ethical approval

The studies involving human participants were reviewed and approved by Ethics committee of the Renji Hospital (No. KY2021-098-B). The patients/participants provided their written informed consent to participate in this study.

ABSTRACT

Background: Hospital discharge readiness is a crucial concept, influenced by various individual, interpersonal, and institutional factors in populations experiencing acute myocardial infarction. However, there is a gap in the exploration of these interactive variables, particularly regarding integrated configurations that facilitate readiness for hospital discharge.

Objective: This study aimed to explore the complex determinants affecting hospital discharge readiness from an integrated perspective, based on the Middle-Range Theory of Adaptation to Chronic Illness.

Methods: A cross-sectional observational study was conducted from July 2021 to March 2024 at a tertiary hospital in Shanghai, China. The study assessed individual demographics, family dynamics, quality of discharge teaching, adaptive capacity, and hospital discharge readiness among post-acute myocardial infarction patients. Fuzzy-set qualitative comparative analysis was employed by performing necessity

and sufficiency analyses of discharge readiness.

Results: A total of 240 patients participated in this study. The findings indicated that no single determinant independently achieved hospital discharge readiness. Six configurations or pathways leading to high readiness were identified, classified into three patient types: (i) hospital-driven, (ii) family-hospital-driven, and (iii) individual-family-hospital joint-driven. Among these, the most significant configuration involved high family dynamics, high quality of teaching prior to discharge, high adaptive capacity, and low-income levels. Substitutability was observed between income levels and family functions across two configurations.

Conclusion: Hospital discharge readiness among post-acute myocardial infarction patients arises from interactions of multiple determinants spanning individual, interpersonal, and institutional levels. These insights can inform healthcare providers to prioritize identifying these factors and developing personalized interventions that enhance adaptive capacity, family dynamics, and teaching quality during transitional care.

Keywords: Hospital discharge readiness; Acute myocardial infarction; Fuzzy-set qualitative comparative analysis; Theory of adaptation to chronic illness

What is already known

- Hospital discharge readiness among patients with acute myocardial infarction is frequently reported as inadequate, leading to long-term disability and adverse events post-discharge.
- Extensive studies have identified individual (e.g., age, education level, economic status), interpersonal (e.g., social support), and institutional determinants (e.g., hospitalization length of stay) that impact hospital discharge readiness, highlighting the need for early interventions in this patient population.

What this paper adds

- This study demonstrates that multiple variables interact in complex ways to

collectively influence hospital discharge readiness among patients with acute myocardial infarction, moving beyond the reliance on a single determinant.

- This study identifies three patient types and six configuration patterns associated with high levels of hospital discharge readiness, with the most significant configuration comprising strong family dynamics, high quality of teaching prior to discharge, high adaptive capacity, and low-income levels.
- Substitutability was observed between individual and interpersonal factors among patients with acute myocardial infarction, indicating that income levels and perceived family functions significantly shape hospital discharge readiness outcomes across two configurations.

1. Introduction

Acute myocardial infarction is a significant global health concern, associated with high morbidity and mortality (Krittanawong et al., 2023). In China, the incidence is estimated at 79.7 cases per 100000 people (Diseases and China, 2024), while the global rate is 38 cases per 100000 (Salari et al., 2023). The growing emphasis on shorter hospital stays and early discharge, driven by economic considerations and ‘enhanced recovery’ care pathways, has introduced early interventions such as angioplasty and cardiac stenting. However, this trend can lead to individuals being unprepared and facing adaptation challenges for acute myocardial infarction patients during the transition from hospital to home, highlighting the need for effective home care management (Fuller et al., 2020). Empirical evidence suggests that at least 69% of patients with acute myocardial infarction exhibit low to intermediate levels of hospital discharge readiness (Hydzik et al., 2021, Kosobucka et al., 2022), which has been associated with adverse post-discharge outcomes (Fuller et al., 2020). Quantitative data indicate suboptimal patient outcomes, with 13.4% of 300,269 patients with acute myocardial infarction experiencing readmission within 30 days (Lemor et al., 2019), and an overall post-discharge 30-day mortality rate of 7.3% among 157,0113 patients (Khera et al., 2020). Conversely, adequate hospital discharge readiness has been positively correlated with improved post-discharge outcomes (Yu et al., 2024). Therefore, further research is essential to enhance the hospital discharge readiness and address the challenges individuals face during the transition to home.

Hospital discharge readiness is a multifaceted concept encompassing various attributes, abilities, and conditions necessary for a patient to transition from hospital care to home. It is defined as the state of being physically and psychologically prepared, equipping individuals who have experienced a cardiac event to manage their care independently at home. This often requires addressing lifestyle-related risk factors, such as high saturated fat intake, lack of physical activity, and smoking, as well as adherence to medications like statins for hyperlipidemia and antihypertensives

for blood pressure control (Galvin et al., 2017). Effective hospital discharge readiness addresses patients' post-discharge needs through seamless continuity of care, thereby reducing hospital readmission, unscheduled clinic visits, and post-discharge coping difficulties, ultimately improving quality of life (Wong et al., 2021, Yu et al., 2024). To improve early discharge support, understanding the determinants influencing hospital discharge readiness among patients with acute myocardial infarction is crucial.

Previous studies have identified various determinants affecting hospital discharge readiness, employing transition theory and the structure-process-outcome model to provide comprehensive insights (Hua et al., 2021, Li et al., 2024, Mabire et al., 2019). Meleis' transitions theory emphasizes that transitions involve changes in an individual's health status, role relationships, expectations, and abilities (Meleis et al., 2000). This process is influenced by four fundamental factors: the nature of the transition (e.g., disease-related information), the conditions surrounding the transition (e.g., demographic information, self-efficacy, social support), the provision of therapeutic care (e.g., quality of teaching prior to discharge), and the response model (e.g., hospital discharge readiness) (Li et al., 2024, Ramsay et al., 2014). This theoretical framework emphasizes both the processes and outcomes of transitions, particularly their implications for individual risk factor-related behavior. In parallel, the structure-process-outcome model highlights that the quality of healthcare can be evaluated through structure (e.g., organizational structure and context, characteristics of healthcare providers and patients), process (e.g., patient perceptions of quality of teaching prior to discharge), and outcome (e.g., hospital discharge readiness), all of which are critical for healthcare organizations (Mabire et al., 2019). Despite these contributions, a significant gap remains in the literature regarding the individual experiences of patients during the discharge process. Further exploration is needed to understand how patients perceive and adapt to transitions, with particular focus on the internal and external resources they utilize that facilitate effective preparation for hospital discharge.

Empirical research has often focused on determinants as independent predictors of hospital discharge readiness among patients with acute myocardial infarction. These determinants include individual factors (e.g., age, education attainment, economic status, acceptance of illness), interpersonal factors (e.g., social support), and institutional factors (e.g., length of hospital stay) (Hydzik et al., 2021, Kosobucka et al., 2022). Conducted in diverse national contexts, these studies have employed linear regression models to establish a solid empirical foundation for enhancing hospital discharge readiness in practice. However, there is a growing recognition of the interactions among determinants across different levels (Fuochi and Foà, 2018, Green et al., 2020). For example, Green et al. (2020) found that individuals with higher education levels reported greater social support, indicating an interplay between individual and interpersonal factors. Despite these insights, few studies have thoroughly explored the integrative effects of these determinants on hospital discharge readiness among patients with acute myocardial infarction. To address this gap, fuzzy set qualitative comparative analysis (fsQCA) is introduced as a method particularly suited to analyzing complex, non-linear relationships. FsQCA captures both the effects of individual variables and their interdependencies, adopting a configurational perspective that allows for the identification of multiple, equally valid pathways leading to an outcome (Blackman et al., 2011; Wang et al., 2023). Its application in diverse healthcare contexts—such as learning engagement (Wang et al., 2024), safety compliance among nurses (Asante et al., 2024), physical activity (Li et al., 2024), and chronic disease management (Gao et al., 2023) — demonstrates its capacity to yield nuanced insights. Accordingly, this study employs fsQCA to examine the complex configurations influencing patient-perceived hospital discharge readiness, aiming to inform clinical practice and health policy on a global scale.

Theoretical background and conceptual model

Given the complex determinants of readiness for hospital discharge, including individual, interpersonal, and institutional factors, this study adopts a systems perspective to explore the adaptation of patients with acute myocardial infarction

during their transition from hospital to home. The Roy Adaptation Model posits that individuals function as holistic adaptive systems requiring continuous exchange of information, materials, and energy with their environments to maintain optimal health (Roy et al., 2009). Building upon the Roy Adaptation Model, the Middle-Range Theory of Adaptation to Chronic Illness elucidates the mechanisms and processes underlying patients' adaptive behaviors in response to disease and coping (Wang and Ye, 2021). As illustrated in **Fig. 1**, this theoretical framework serves as a research hypothesis to examine the interrelations among the complex determinants of hospital discharge readiness, viewing readiness as an outcome of adaptation.

According to the Middle-Range Theory of Adaptation to Chronic Illness, stimuli serve as triggers essential for activating the human system and its interaction with the environment. The diagnosis of acute myocardial infarction presents significant stressors for patients, acting as focal stimuli. Contextual stimuli, such as socio-demographic factors (e.g., age, education, income), are recognized as significant determinants affecting hospital discharge readiness among patients with acute myocardial infarction (Hydzik et al., 2021, Kosobucka et al., 2022). Additionally, family dynamics, representing an integral element of social support, encompasses the relationships among family members and their interactions (Smith et al., 2022). Integrating family support into the rehabilitation process is crucial in cultures that emphasize extended family interactions (Nguyen et al., 2023), highlighting its role as a crucial resource to illness recovery, especially as cardiovascular disease is a chronic long-term condition. Moreover, social support is reinforced through discharge teaching, wherein healthcare professionals educate patients and their families about managing health post-discharge. This education includes guidance on lifestyle modifications—primarily related to diet and physical activity—medication adherence, and responding to chest pain or other cardiac-related symptoms. The quality of teaching prior to discharge is primarily reflected in patients' perceptions of the effectiveness of the education they receive (Pellet et al., 2024). Research indicates that the quality of teaching for patients following percutaneous

coronary intervention (PCI) is strongly linked to hospital discharge readiness and effective self-management (Yang et al., 2024).

Regarding adaptive capacity, the coping processes and adaptive abilities of patients with acute myocardial infarction are seen as interactive, influenced by illness perceptions, subjective appraisals of stimuli, and various demographic, familial, social, and cultural factors. Studies involving patients undergoing long-term cardiac rehabilitation indicate a tendency to develop adaptive tasks and engage in adaptive processing of information (Wang et al., 2024, Wang et al., 2023). Living with acute myocardial infarction and subsequent chronic conditions requires individuals to discover new coping strategies as they adjust to their long-term condition. These internal coping mechanisms, along with the utilization of external interpersonal and institutional support established during hospitalization, are crucial indicators of hospital discharge readiness, yet they remain underexplored in the literature. **Fig. 1** presents a conceptual-theoretical-empirical framework for hospital discharge readiness based on the Middle-Range Theory of Adaptation to Chronic Illness among patients with acute myocardial infarction.

2. Methods

2.1. Aim

This study aims to explore the interactions among determinants affecting hospital discharge readiness, as informed by the Middle-Range Theory of Adaptation to Chronic Illness.

2.2. Study design

This study is part of a longitudinal project focusing on the rehabilitation and adaptation of patients with acute myocardial infarction. Data on hospital discharge readiness were collected as baseline measurements from July 2021 to March 2024.

2.3. Study setting and participants

The study was conducted at a tertiary hospital in Shanghai, which comprises four campuses and serves as a leading facility in collaboration with the Pudong New Area district medical group, providing healthcare services to a local community health

system encompassing a population of approximately 5.68 million. Trained nurses facilitated recruitment within 24 hours prior to the discharge of patients with acute myocardial infarction. The eligibility criteria for participation included: (1) being aged 18 years or older, (2) having a diagnosis of first-time acute myocardial infarction, (3) having received percutaneous coronary intervention (PCI) treatment, and (4) having willingness to participate. The exclusion criteria were as follows: (1) transition to other tertiary hospitals, and (2) disabilities that impair the ability to read the surveys or communicate with others. Participants were fully informed about the study's purpose, survey contents, and investigation processes, and they had the right to withdraw at any time.

2.4. Measures

As illustrated in **Fig. 1** for testing the research hypothesis within the Middle-Range Theory of Adaptation to Chronic Illness, several instruments were employed in this study.

Sociodemographic data and illness-related information

Sociodemographic data were collected through self-report surveys to assess contextual stimuli. The variables included for analysis were age, education attainment (primary school or below, junior middle school, high school or technical secondary school, junior college, bachelor's degree, master's degree or above), and average monthly household income levels, which was classified into the following categories: <4000 CNY (approximately 560 USD), 4000-8000 CNY (560–1,120 USD), 8000-12000 CNY (1,120–1,680 USD), 12000-16000 CNY (1,680–2,250 USD), and >16000 CNY (2,250 USD). A threshold of 4,000 CNY was used as a proxy for the low-to-middle income boundary, based on 2024 national and regional averages—3,443 CNY nationally and 7,364 CNY in Shanghai—reported by the National Bureau of Statistics and the Shanghai Municipal Bureau of Statistics (2025). To reflect China's socioeconomic diversity, income was further stratified by sample-specific percentiles. A threshold of 12,000 CNY was used in the analysis to evaluate the impact of income distribution on discharge readiness, based on the

distribution within the study sample. Additional variables, including gender, marital status, primary caregiver, comorbidities, myocardial infarction type, and coronary artery trunk lesion status, were also collected. However, informed by previous research (Hydzik et al., 2021; Kosobucka et al., 2022), these factors were excluded from the final analysis due to their lack of statistical significance or lower predictive value compared to age, education, and income (see Supplementary Table 1). Although education and income were not statistically significant as independent variables, their frequent co-occurrence in sufficient configurations associated with general health outcomes supports their inclusion (Hao et al., 2023). Therefore, age, educational attainment, and income were retained as the primary sociodemographic variables in the final analysis.

The Self-Rating Scale of Systemic Family Dynamics (SSFD)

The Self-Rating Scale of Systemic Family Dynamics (SSFD) was utilized to evaluate family support within the contextual stimuli by assessing individuals' perceptions of family dynamics (Yang et al., 2002). The revised version of SSFD has a total of 23 items, and includes the following four dimensions: family atmosphere (FA), individuation (IN), system logic (SL), and illness concepts (IC). It was rated on a five-point scale, the possible scores range from 23 to 115, and higher scores indicate stronger family functions. The revised version of the SSFD had an overall Cronbach's α coefficient of 0.79, and 0.58-0.83 for the four dimensions (Yu et al., 2014). The Cronbach's α for the scale in this study was 0.742.

The Quality of Discharge Teaching Scale (QDTS)

To assess institutional factors related to contextual stimuli, the Quality of Discharge Teaching Scale (QDTS), developed by Weiss et al. (Weiss et al., 2007), was employed. This scale comprises 24 items divided into three dimensions: content needed (6 items), content received (6 items), and teaching skills and effects (12 items). The total scale score is calculated by adding the content received and teaching skills and effects scores, using a 10-point scoring method; the possible scores range from 0 to 180, and a higher score indicates more satisfactory teaching quality (Weiss et al.,

2007). In the study of Weiss et al., the Cronbach's α coefficient for the QDTS was 0.92, and that for the content received and teaching skills and effects subscales was 0.85 and 0.93, respectively (Weiss et al., 2007). The translated and Chinese adapted version obtained an overall Cronbach's α coefficient of 0.924, and 0.882–0.935 for the three dimensions (Wang et al., 2016). The Cronbach's α coefficient of this scale in the current study was 0.806.

The Readiness for Hospital Discharge Scale

The Readiness for Hospital Discharge Scale, developed by Weiss and Piacentine (Weiss and Piacentine, 2006), measures readiness for hospital discharge as an adaptation outcome. The scale comprises 23 items categorized into four dimensions: physical conditions (7 items), knowledge (8 items), coping ability (3 items) and expected support (4 items), and a true/false item (excluded from scoring). Cronbach's α was 0.90, and 0.69-0.87 for its subscales (Weiss and Piacentine, 2006). The translated and Chinese adaptation version with three dimensions: personal status (4 items), coping ability (4 items), and expected support (4 items), obtained an overall Cronbach's α coefficient of 0.89 (Lin et al., 2014). A 10-point scoring method is used, with possible scores ranging from 0 to 120. The higher the score, the better the patient's hospital discharge readiness. An average score of 9-10 for each item is considered a very high level of hospital discharge readiness; 8.0~8.99 is considered a high level of hospital discharge readiness; 7.0 ~7.99 is considered a median level of hospital discharge readiness; below 7.0 denotes a very low level of hospital discharge readiness. In this study, the overall Cronbach's α coefficient of this scale was 0.915.

The Chinese Coping and Adaptation Processing–Short Form (C-CAPS-SF)

To assess adaptive capacity, the Chinese Coping and Adaptation Processing–Short Form (C-CAPS-SF), a culturally adapted and psychometrically validated instrument developed by Wang et al. (2020) was used. The C-CAPS-SF is derived from the original Coping and Adaptation Processing–Short Form (CAPS-SF), initially developed by Roy et al. (2016), which conceptualizes coping as a dynamic and multidimensional response to environmental and internal stimuli. Specifically, the

CAPS-SF framework encompasses cognitive appraisal (the individual's subjective evaluation of illness-related factors such as severity, controllability, and emotional impact), information processing, and resultant behavioral responses. The C-CAPS-SF has undergone rigorous validation in a sample of 288 Chinese patients with cardiovascular conditions, demonstrating satisfactory psychometric properties. The instrument comprises four subscales: Resourceful and Focused, Self-Initiated and Knowing-Based, Physical and Fixed, and Positive and Systematic. It employs a four-point Likert scale (1 = never, 4 = always), yielding total scores ranging from 15 to 60, with higher scores indicating more frequent and consistent use of adaptive coping strategies. As a summative scale, the C-CAPS-SF exhibited a McDonald's omega of 0.82 for the total scale, with subscale omega coefficients ranging from 0.56 to 0.88, reflecting acceptable to strong internal consistency (Wang et al., 2020). In this study, the Cronbach's α of the C-CAPS-SF was 0.661, indicating acceptable internal consistency.

2.5. Data collection

Data collection was conducted by nurses who were nationally registered and were full-time employees at the hospital. A standardized discharge process was in place, with clearly defined roles for bedside nurses. All nurses in the cardiology department who voluntarily participated in the study received 3 hours of training on the recruitment process from the chief nurse manager to ensure consistency and accuracy. In approaching potential participants, the trained nurses verbally introduced the study and engaged them in either Chinese Mandarin or the local Shanghai dialect to minimize misunderstandings. Participants were recruited through face-to-face assessments using structured questionnaires with clear instructions. Informed consent was obtained via a written consent form, ensuring participants fully understood the study's purpose and procedures. They were explicitly informed that their decision to participate or decline would not impact their treatment, care, or relationship with the nurses, and that they could withdraw from the study at any time without consequence. Nurses were available to address any questions or concerns, maintaining neutrality in

response to the participants' answers. Completed surveys were securely stored in the department with key-based access control to ensure confidentiality and protect participant information.

2.6. Statistical analysis

Descriptive analyses, including frequencies, percentages, means, and standard deviations (SD), were computed using SPSS 24.0 software. To examine the complex determinants of hospital discharge readiness, fsQCA 4.1 software was utilized, with findings reported according to the guidelines of Ragin and Fiss (Ragin and Fiss, 2008). The operational steps of the fsQCA method used in this study are presented in **Fig. 2**.

In fsQCA, the adequacy of the sample size is critically dependent on the number of conditions included in the analysis. Following the 2^k rule, where k represents the number of conditions (Ragin., 2009; Farrugia., 2019), the sample size must meet a threshold to ensure diversity and validity (Ragin et al., 2005). Although fsQCA was originally designed for small sample sizes ($n < 15$), it has been adapted for larger samples ($n > 100$) in recent research due to the inclusion of more conditions (Wang et al., 2023). Typically, the recommended range for the number of determinants is between 4 and 7, with no more than 10, as an excessive number of conditions may hinder meaningful interpretation (Wang et al., 2023). The selection of determinants should be grounded in relevant theoretical and practical considerations, using either inductive or deductive methods (Wang et al., 2023). The focus is not solely on univariate analysis results but on identifying conjunctural associations (Gao et al., 2023; Hao et al., 2023; Wang et al., 2024), guiding the identification of factors predictive of hospital discharge readiness in this study.

Calibration is a crucial step in the fsQCA process, transforming original data into fuzzy sets to assess how the degree of presence or absence of a condition influences the outcome. Calibration involves establishing three critical values—fully affiliated, crossover, and fully unaffiliated—based on theoretical or conceptual frameworks, with affiliation values ranging from 0 to 1. Following established guidelines, the 0.95th (representing full membership), 0.50th (crossover point indicating maximum

ambiguity), and 0.05th (denoting full non-membership) percentiles of the data are utilized in the calibration function (Ong and Johnson, 2023; Rihoux et al., 2008). As defined by Frazier et al. (2016), the 50th percentile of the condition/outcome distribution served as the threshold for classification indicating the condition's presence or absence was indeterminate: values above this percentile were categorized as "high", denoting the presence of the condition/outcome, while values below this percentile were categorized as "low", indicating its absence or weakly presence. After calibration, values equal to 0.5 are manually corrected to 0.501. Furthermore, anchor points can be established using alternative percentiles, such as 90th, 50th, and 10th percentiles or 75th, 50th, and 25th percentiles, to represent full affiliation, intersection, and full non-affiliation, respectively (Woodside, 2014; Fiss, 2011).

Following calibration, the necessity of each antecedent variable for hospital discharge readiness is assessed before conducting sufficient analysis. An antecedent variable is deemed necessary if its value exceeds 0.90 (Zhang and Du, 2019). A truth table for sufficient analysis is constructed, with consistency set at 0.8 and frequency at 2, ensuring retention of at least 75% to 80% of observation cases (Wang et al., 2023). Variables appearing in both parsimonious and intermediate solutions are classified as core conditions, while those appearing only in intermediate solutions are classified as edge conditions (Fernández-García et al., 2021). A solution consistency of 0.750 or higher indicates that the model is informative (Eng and Woodside, 2012).

The fsQCA also involves modifying calibration points, case frequency thresholds, and consistency thresholds for robustness testing (Wang et al., 2023). Two key assessment indices are used for evaluation: configuration results and overall solution consistency and coverage. A clear subset relationship among different configuration results indicates robustness. Furthermore, if variations in consistency and coverage do not significantly alter substantive interpretations, the results can also be considered robust (Wang et al., 2023).

2.5. Ethics approval and consent to participate

The study adhered to the Declaration of Helsinki and was approved by the Ethics

Committee of a university-affiliated Hospital (No. KY2021-098-B). All participants were informed of the study design and provided their informed written consent. Confidentiality of all data was ensured, and participants were made aware of their right to withdraw from the study voluntarily at any time.

3. Results

3.1 Descriptive statistics

A total of 240 patients with acute myocardial infarction participated in the study, yielding a 100% response rate. As shown in **Table 1**, the average age of the participants was 61.93 years ($SD \pm 11.62$). In terms of educational attainment, 32.9% ($n = 79$) had completed high school or technical secondary school, while only 2.1% ($n = 5$) held a master's degree or higher. Regarding monthly income, 32.9% ($n = 79$) reported incomes between 4000 and 8000 CNY (approximately 560 USD - 1,120 USD), and 12.9% ($n = 31$) reported incomes below 4000 CNY (approximately 560 USD). The mean score for hospital discharge readiness was 83.764 ($SD = 12.728$), indicating a low level of readiness for hospital discharge, with an average item score of 6.980 ($SD = 1.061$). Further detailed information is shown in **Table 1**.

Table 1

Descriptive statistics of the characteristics of the sample ($n=240$).

Condition		N (%) / (Mean $\pm$ SD)
Age		61.930 $\pm$ 11.620
Education attainment	1=Primary school or below	18(7.5)
	2=Junior middle school	68(28.3)
	3=High school or technical secondary school	79(32.9)
	4=Junior college	32(13.3)
	5=Bachelor's degree	38(15.8)
	6=Master's degree or above	5(2.1)
Average monthly household income levels	1=<4000 CNY (560 USD)	31(12.9)
	2=4000-8000 CNY (560 USD-1,120 USD)	79(32.9)
	3=8000-12000 CNY (1,120 USD-1,680 USD)	61(25.4)

	4=12000-16000 CNY (1,680 USD-2250 USD)	36(15.0)
	5=>16000 CNY (2250 USD)	33(13.8)
Adaptive capacity		68.278±13.470
Family dynamics		70.435±11.164
Teaching quality		87.394±13.280
Readiness for hospital discharge		83.764±12.728

3.2 Calibration

According to three thresholds (0.95th, 0.50th, and 0.05th) based on a previous study (Ong and Johnson, 2023), the study converted age, education attainment, monthly income, adaptive capacity, family dynamics, teaching quality prior to discharge, and readiness for hospital discharge scale into a fuzzy membership. The calibration values for all included variables are detailed in **Table 2**.

Table 2

Condition assignment and calibration parameters for fsQCA.

Condition	Assignment	95 % percent ile	Me dia n	5 % percen tile
Age	Years old	80	63	43.900
	1=Primary school or below			
	2=Junior middle school			
	3=High school or technical			
Education attainment	secondary school	5	3	1
	4=Junior college			
	5=Bachelor's degree			
	6=Master's degree or above			
Average monthly household income levels	1=<4000 CNY (560 USD)	5	3	1
	2=4000-8000 CNY (560 USD-1,120 USD)			
	3=8000-12000 CNY (1,120 USD-1,680 USD)			
	4=12000-16000 CNY (1,680 USD-2250 USD)			
	5=>16000 CNY (2250 USD)			
Adaptive capacity	Total score	89.001	68.890	44.440
Family dynamics	Total score	85.925	70.650	52.170

Teaching quality	Total score	100	89.440	60.504
Readiness for hospital discharge	Total score	100	85	62.459

3.3 Necessity analysis of hospital discharge readiness to identify determinants

Table 3 presents the results of the necessity test regarding the impact of each determinant—age, educational attainment, income levels, adaptive capacity, family dynamics, and teaching quality prior to discharge—on hospital discharge readiness. The results indicate that no single determinant exceeded the consistency threshold of 0.900, suggesting that no single factor serves as a necessary condition for hospital discharge readiness. This confirms that readiness is influenced by a complex interplay of multiple determinants rather than being directly attributed to any single determinant.

Table 3

Analysis of the necessary conditions for hospital discharge readiness.

Condition	Consistency	Coverage
Age	0.550	0.600
~Age	0.701	0.727
Education attainment	0.638	0.676
~Education attainment	0.604	0.640
Average monthly household income levels	0.562	0.667
~Average monthly household income levels	0.689	0.659
Adaptive capacity	0.698	0.723
~Adaptive capacity	0.575	0.623
Family dynamics	0.725	0.751
~Family dynamics	0.538	0.584
Teaching quality	0.832	0.781
~Teaching quality	0.428	0.521

“~” represents negation

3.4 Sufficiency analysis of hospital discharge readiness to identify configurations of high hospital discharge readiness

The sufficiency analysis, presented in **Table 4**, reveals that six configurations collectively accounted for 63.5% of patients exhibiting high levels of hospital discharge readiness (overall coverage = 0.635, overall consistency = 0.886), with readiness scores exceeding 85. Notably, the quality of nurses’ teaching was present in

all configurations, demonstrating a high level of performance, with scores exceeding 89.440. The most significant configuration explaining high hospital discharge readiness comprised the absence of income, alongside the presence of adaptive capacity, family dynamics, and teaching quality. Specifically, this configuration corresponded to low-income levels (below 12000 CNY/1,680 USD), high adaptive capacity (scores above 68.890), strong family dynamics (scores above 70.650), and high teaching quality (scores above 89.440), accounting for 41.1% of patients demonstrating high readiness (raw coverage = 0.411, raw consistency = 0.906). Additionally, configurations 1 and 4 indicated that high-income levels and strong family dynamics could be interchangeable.

Table 4

Analysis of the configurations for hospital discharge readiness.

Condition	Configurations					
	1	2	3	4	5	6
Age	⊗	⊗	⊗	⊗		
Education attainment	●	⊗		●	⊗	
Average monthly household income levels	●	⊗	⊗			⊗
Adaptive capacity		⊗			●	●
Family dynamics			●	●	●	●
Teaching quality	●	●	●	●	●	●
Raw coverage	0.360	0.286	0.380	0.390	0.384	0.411
Unique coverage	0.032	0.017	0.003	0.002	0.016	0.020
Consistency	0.899	0.929	0.934	0.926	0.906	0.906
Solution coverage	0.635					
Solution consistence	0.886					

Note: “●” and “●” indicated presence of core and edge conditions, respectively, signifying classification into a high level, with scores exceeding the 50th percentile of the condition/outcome distribution; “⊗” and “⊗” indicated absence of core and edge conditions, respectively, corresponding to classification into a low level, with scores

falling below the 50th percentile of the condition/outcome distribution; blank spaces indicated “do not care”, implying that they do not contribute to or alter the configuration's influence on the outcome

A detailed interpretation of the six configurations is provided below:

Configuration 1: ~age*education attainment*income levels*teaching quality

Configuration 1 was characterized by the absence of age, coupled with the presence of educational attainment, income levels, and teaching quality. The raw coverage value for Configuration 1 was 0.360, indicating that 36.0% of patients with high levels of hospital discharge readiness (scores above 85) were younger than 63 years, possessed high educational attainment (junior college or above), high income (12000 CNY/1,680 USD or more), and received high quality of teaching (scores above 89.440). Since age, education, and income are less easily altered, while teaching quality is modifiable, these patients were categorized as “hospital-driven patients” (see Fig. 2).

Configuration 2: ~age*~education attainment*~income levels*~adaptive capacity*teaching quality

Configuration 2 included the absence of age, education attainment, income levels, and adaptive capacity, alongside the presence of teaching quality. With a raw coverage value of 0.286, Configuration 2 encompassed 28.6% of patients who were younger than 63 years, had low educational attainment (junior middle school or below), low income (below 12000 CNY/1,680 USD), and low adaptive capacity (scores below 68.890), yet received high teaching quality (scores above 89.440). Given the importance of teaching quality as a modifiable variable, these patients were also classified as “hospital-driven patients” (see Fig. 3).

Configuration 3: ~age*~income levels*family dynamics*teaching quality

Configuration 3 was defined by the absence of age and income levels, with the presence of family dynamics and teaching quality. The raw coverage value of 0.380 for Configuration 3 indicates that 38.0% of patients with high hospital discharge readiness (scores above 85) were younger than 63 years, had low income (below

12000 CNY/1,680 USD), high family dynamics (scores above 70.650), and received high teaching quality (scores above 89.440). As family dynamics and teaching quality are modifiable variables, these patients were labeled as “family-hospital driven patients” (see Fig. 3).

Configuration 4: $\sim$ age*education attainment*family dynamics*teaching quality

Configuration 4 was characterized by the absence of age and the presence of education attainment, family dynamics, and teaching quality. Configuration 4 had a raw coverage value of 0.390, showing that 39.0% of patients were younger than 63 years, had high educational attainment (junior college or above), high family dynamics (scores above 70.650), and high teaching quality (scores above 89.440). Given that both family dynamics and teaching quality are modifiable, these patients were also classified as “family-hospital driven patients” (see Fig. 3).

Configuration 5: $\sim$ education attainment*adaptive capacity*family dynamics*teaching quality

Configuration 5 included the absence of education attainment and the presence of adaptive capacity, family dynamics, and teaching quality. The raw coverage value of configuration 5 was 0.384, showing that 38.4% of patients with high levels of hospital discharge readiness (scores above 85) had low education attainment (junior middle school or below), high adaptive capacity (scores above 68.890), high family dynamics (scores above 70.650), and high teaching quality (scores above 89.440). Because all three factors are modifiable, these patients were categorized as “individual-family-hospital joint-driven patients” (see Fig. 3).

Configuration 6: $\sim$ income levels*adaptive capacity*family dynamics*teaching quality

Configuration 6 was defined by the absence of income levels, as well as the presence of adaptive capacity, family dynamics, and teaching quality. Configuration 6 presented a raw coverage value of 0.411, indicating that 41.1% of patients had low income (below 12000 CNY/1,680 USD), high adaptive capacity (scores above

68.890), high family dynamics (scores above 70.650), and high teaching quality (scores above 89.440). Similarly, as all three factors are modifiable, these patients were labeled as “individual-family-hospital joint-driven patients” (see **Fig. 3**).

3.5 Robustness test for supporting the identified configurations

To assess the robustness of the study's results, several tests were conducted. First, the calibration points were adjusted from the 95th, 50th, and 5th percentiles to the 90th, 50th, and 10th, and then to the 75th, 50th, and 25th percentiles for the first robustness test. Second, the case frequency threshold was modified from "2" to "3" for the second test. Finally, the consistency threshold was increased from "0.80" to "0.85" for the third robustness test. **Table 5** presents the findings of these robustness tests.

Following the adjustments to the case frequency and consistency thresholds, all six configurations remained intact, demonstrating the robustness of the original configurations and their insensitivity to parametric variations in frequency thresholds and consistency criteria. However, when the calibration points were adjusted from the 95th, 50th, and 5th percentiles to the 90th, 50th, and 10th percentiles, original configurations 1 and 3 were absent among the new configurations. Despite this, the overall solution coverage (0.576) and consistency (0.880) remained highly consistent with the original values (overall coverage = 0.635, overall consistency = 0.886). Similarly, when the calibration points were further adjusted to the 75th, 50th, and 25th percentiles, original configuration 3 was absent in the new configurations, but the overall solution coverage (0.505) and consistency (0.875) continued to align closely with the original values (overall coverage = 0.635, overall consistency = 0.886). Thus, these original configurations were deemed robust, suggesting that the identified configurations exhibit a high degree of stability and reliability.

Table 5

Robustness test results.

	(1)	(2)	(3)	(4)
The original configurations	Changed threshold	Changed threshold	Changed case frequency	Changed the consistency
	s	s	form	form

	95th, 50th, 5th to 90th, 50th, 10th	95th, 50th, 5th to 75th, 50th, 25th	y threshold s from 2 to 3 cases	y from 2 to 0.85	score 0.8
Configuration 1 (~age*education attainment*income levels*teaching quality)		√	√	√	
Configuration 2 (~age*~education attainment*~income levels*~adaptive capacity*teaching quality)	√	√	√	√	
Configuration 3 (~age*~income levels* family dynamics*teaching quality)			√	√	
Configuration 4 (~age*education attainment*family dynamics*teaching quality)	√	√	√	√	
Configuration 5 (~education attainment *adaptive capacity*family dynamics*teaching quality)	√	√	√	√	
Configuration 6 (~income levels*adaptive capacity*family dynamics*teaching quality)	√	√	√	√	
Overall solution coverage: 0.635	0.576	0.505	0.635	0.635	
Overall solution consistency: 0.886	0.880	0.875	0.886	0.886	

Note: √ means the solution exists; blank spaces mean the solution does not exist.

4. Discussion

This study represents the first investigation into the complex determinants influencing hospital discharge readiness among patients with acute myocardial infarction using the fsQCA approach, based on the Middle-Range Theory of Adaptation to Chronic Illness. The findings reveal that individual, interpersonal, and institutional factors do not serve as standalone necessary conditions for discharge readiness; instead, their

interactions and synergistic effects play a vital role. Six distinct configurations were identified and categorized into three patient types, each contributing to enhanced levels of hospital discharge readiness. Robustness testing confirmed the stability of the complex, non-linear relationships, supporting the validity and generalizability of the findings.

This study identifies two configurations that exemplify "hospital-driven patients" and highlight the interplay between individual characteristics and discharge teaching quality in shaping hospital discharge readiness. Configuration 1 ($\sim\text{age} * \text{education attainment} * \text{income levels} * \text{teaching quality}$) indicates that younger patients with higher education, higher income, and high-quality discharge teaching exhibit greater readiness, likely due to enhanced capacity to understand and implement discharge instructions (Yu et al., 2024, Hydzik et al., 2021, Kolarczyk et al., 2023). Configuration 2 ($\sim\text{age} * \sim\text{education attainment} * \sim\text{income levels} * \sim\text{adaptive capacity} * \text{teaching quality}$) further emphasizes the compensatory power of teaching quality. In this case, younger patients with limited socioeconomic and adaptive resources still exhibited high readiness when exposed to effective discharge education, aligning with previous findings that highlight the mitigating effect of tailored instruction (Guan and Feng, 2023, Yu et al., 2024, Zhang et al., 2021). Collectively, these configurations reinforce the pivotal role of nurse-led discharge teaching in supporting diverse patient groups. To enhance discharge outcomes, structured educational frameworks should be grounded in multidisciplinary collaboration and extend beyond hospital settings through strategies such as telephonic follow-up, home visits, and community-based outreach. Central to this approach is the application of health-literacy-sensitive methodologies—including visual aids, teach-back techniques, and culturally competent communication—which are essential for improving comprehension and adherence among patients with limited health literacy. Such targeted, evidence-informed strategies contribute to more effective, equitable, and sustainable discharge processes.

Another key finding pertains to the "family-hospital driven" configurations,

specifically configuration 3 ($\sim$ age $\times$ $\sim$ income levels $\times$ systemic family dynamics $\times$ teaching quality) and configuration 4 ($\sim$ age $\times$ education attainment $\times$ systemic family dynamics $\times$ teaching quality). These configurations demonstrate that strong family functioning, when paired with high-quality discharge teaching, can effectively offset socioeconomic disadvantages and enhance hospital discharge readiness. This is consistent with the Middle-Range Theory of Adaptation to Chronic Illness, based on the Roy Adaptation Model, which conceptualizes individuals as adaptive systems responding to environmental stimuli through four adaptive modes: physiological, self-concept, role function, and interdependence. discharge education enhances the self-concept and role function modes by improving knowledge, confidence, and preparedness for self-care, while robust family support contributes to the interdependence mode through emotional and instrumental assistance. For socioeconomically disadvantaged patients, family systems often act as resource substitutes, buffering the effects of structural barriers (Chen et al., 2024). When individuals perceive themselves as unable to manage post-discharge challenges independently, trust in healthcare professionals and reliance on family members typically increase, enhancing adherence to discharge instructions (Cui et al., 2023). High-quality discharge education delivered in the context of a supportive family further improves communication, clarifies caregiving responsibilities, and facilitates a smoother transition from hospital to home (Klingbeil et al., 2022). Additionally, Configuration 4 suggests that individuals with higher educational attainment tend to exhibit stronger family functioning, which further amplifies the effectiveness of discharge teaching (Zeng et al., 2022; Yu et al., 2024). These findings reinforce the theoretical perspective that adaptation is influenced by both internal coping capacities and external support systems, highlighting the importance of integrating family-centered approaches into discharge planning. Key strategies include assessing caregiver needs, delivering tailored home-care training, such as symptom monitoring and medication management, evaluating caregiver readiness, and providing ongoing support through in-person, virtual, or telephone follow-up. By fostering adaptive

responses from a holistic perspective, these interventions can strengthen post-discharge recovery and reduce the risk of readmission among socioeconomically vulnerable patients.

The findings regarding the “individual-family-hospital joint-driven” configurations, specifically configuration 5 (~education attainment*adaptive capacity*systemic family dynamics*teaching quality) and configuration 6 (~income levels*adaptive capacity*systemic family dynamics*teaching quality). These results demonstrate that strong personal adaptive capacity, when supported by effective family functioning and high-quality discharge teaching, can mitigate the impact of educational and financial disadvantages on hospital discharge readiness. These results align with the Roy Adaptation Model, which posits that adaptive capacity is a fundamental aspect of self-management and emotional regulation through the regulator and cognator subsystems (Jennings, 2017). When adaptive capacity is bolstered by strong family dynamics and structured discharge education, patients, even those with low socioeconomic status, are better equipped to navigate the transition from hospital to home. Research indicates that social support and effective teaching positively influence adaptive capacity (Chen et al., 2023) suggesting that both individual resilience and family support are vital for improving discharge readiness. Patients with higher adaptive capacity are more likely to manage post-discharge health issues and adapt to changes, resulting in better outcomes. Addressing coping patterns related to low literacy or limited social capital is essential for improving discharge outcomes, particularly in vulnerable populations (Morgan and Yoder, 2012). While adaptive capacity develops over time, its foundation is established during hospitalization, highlighting the importance of comprehensive discharge training that extends beyond discharge-day instructions. Interventions such as involving patients, family caregivers, and healthcare providers in discharge education, offering clear and straightforward health education, and ensuring access to follow-up health resources are essential strategies to mitigate the effects of low literacy and socioeconomic disadvantage. The individual-family-hospital joint-driven

model suggests that future research should focus on the integration of tailored discharge teaching, enhanced nurse competencies, and family-centered care strategies to optimize recovery and reduce readmission rates. Longitudinal studies examining the dynamic interactions among individual, familial, and institutional factors, utilizing a multidimensional approach informed by mobile health (mHealth) technologies and artificial intelligence (AI)-driven solutions (Deniz-Garcia et al., 2023), are needed to validate these findings and refine evidence-based interventions for discharge readiness across diverse patient populations. Additionally, the development of predictive models will facilitate the optimization of care delivery standards and operational productivity, ensuring the sustainability and effectiveness of transitional care.

Additional significant findings from Configurations 1 and 4 indicate that among young, highly educated patients receiving high-quality teaching prior to discharge, both high income and strong family functions can independently enhance hospital discharge readiness. This pattern suggests a substitutability effect between financial resources and family support—where the presence of one can compensate for the absence of the other. In collectivist cultural contexts such as China, familial networks frequently serve as compensatory structures that address resource gaps, particularly financial limitations, thereby mitigating socioeconomic disparities in healthcare outcomes (Chen et al., 2024). Cultural norms emphasizing filial responsibility and shared caregiving obligations reinforce continuity of care and emotional stability during the post-discharge period. This interaction underscores how economic and familial support mechanisms can independently or synergistically enhance discharge preparedness (Wang and Cheng, 2024). Consequently, healthcare professionals should prioritize strengthening family functioning in discharge planning, especially for patients from low-income backgrounds, although this finding warrants further empirical validation.

This study empirically extends the Middle-Range Theory of Adaptation to Chronic Illness by providing evidence for its application in understanding hospital discharge readiness. Theoretical implications include the operationalization of

concepts and the exploration of complex, non-linear relationships through fsQCA analysis. Six configurations were identified, each comprising 4 to 5 determinants based on fsQCA analysis, which challenges the notion that these variables operate independently in influencing hospital discharge readiness (Hydzik et al., 2021, Kosobucka et al., 2022, Mabire et al., 2019). The findings validate the theory by examining the complex determinants within its constructs, enhancing the understanding of cognitive and adaptive processes in discharge preparation, and refining the role of adaptive capacity in fostering adaptive behaviors. Unlike previous studies that examined the net effects of determinants from a linear perspective (Shao et al., 2022), this study illustrates how interactions among determinants contribute to hospital discharge readiness. This approach enriches the theoretical framework by highlighting the dynamic interplay between personal, familial, and institutional factors in the adaptation process. From a practical standpoint, this study informs an integrated, theory-guided intervention framework. It emphasizes the importance of adaptive capacity, family dynamics, and discharge teaching in shaping discharge readiness and advocates for standardized nurse-led discharge protocols, family function enhancement, and individualized adaptive capacity programs. These insights enable healthcare professionals to tailor discharge preparation programs to meet individual patient needs, ensuring smoother transitions to home care and improving patient outcomes. Overall, these findings contribute to enhancing the Roy Adaptation Model through cultural and scientific hypothesis testing, further advancing its application in nursing research and practice.

Several limitations should be considered when generalizing these findings. First, while the study was conducted in a tertiary hospital in Shanghai with a broad community service scope, further validation in different healthcare settings and regions is needed. Future research should consider replicating this study in hospitals of varying levels (e.g., primary, secondary, and tertiary) and across diverse geographic areas (e.g., metropolitan, regional, suburban, and areas with varying income levels) to better assess the influence of socioeconomic and contextual factors. Second, while the

study addressed complex, non-linear relationships, the roles of family caregivers in post-acute myocardial infarction recovery—such as emotional support, behavioral management, and symptom monitoring—require further exploration (Yates et al., 2018). Within the Chinese sociocultural context, influenced by collectivism, filial piety, and mutual support, additional factors related to family caregivers (e.g., marital status, relationship with patients, cohabitation status, and family dynamics) should be examined from various theoretical perspectives (e.g., family systems theory) to provide a more comprehensive understanding of discharge readiness. Third, the study focused on six determinants derived from the Middle-Range Theory of Adaptation to Chronic Illness, but the inclusion of organizational factors could provide a more comprehensive understanding of discharge outcomes. Although the study explored high-readiness configurations, it did not address low-readiness pathways, as the primary objective was to inform targeted interventions for enhancing discharge preparedness. Future research could examine low-readiness configurations and develop predictive models to facilitate early risk identification and intervention. Additionally, the measurement of adaptive capacity demonstrated marginal reliability (Cronbach's $\alpha = 0.661$), below the conventional threshold for acceptable internal consistency. This may reduce precision in capturing individual coping and adaptation processes. However, interpreting findings as indicative patterns rather than definitive effects helps mitigate this limitation. Future studies could enhance measurement reliability through cognitive interviewing or detailed exploration of patients' lived experiences. Lastly, while fsQCA has been positioned as a 'third way' bridging qualitative and quantitative research, its ability to support causal inference is inherently limited. Thus, complementary longitudinal and interventional studies are necessary to validate the identified causal pathways and further investigate adaptation mechanisms and health outcomes.

5. Conclusion

This study elucidated the interactions among determinants influencing hospital discharge readiness in individuals recovering from acute myocardial infarction based

on the Middle-Range Theory of Adaptation to Chronic Illness framework. The identified configurations associated with better hospital discharge readiness underscore the significance of individual, interpersonal, and institutional determinants, which collectively inform future interventions and clinical practice. Healthcare providers should prioritize the early initiation of discharge preparation programs, focusing on enhancing adaptive capacity, strengthening family dynamics, and improving discharge education quality to support a successful transition from hospital to home.

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Fig. 1. Conceptual-theoretical-empirical framework for the hospital discharge readiness based on the Middle-Range Theory of Adaptation to Chronic Illness.

Fig.2. Basic steps in fsQCA method.

Fig. 3. Identified six configurations and three patient types of high hospital discharge readiness.

Note: presence of core and edge conditions, signifying classification into a high level, with scores exceeding the 50th percentile of the condition/outcome distribution; absence of core and edge conditions, corresponding to classification into a low level; with scores falling below the 50th percentile threshold

Data availability statement

Data are available from the first author or corresponding author on reasonable request.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.