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Translation, validation, predictive analysis of the Italian version of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey and symptom cluster characterization in women

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ABSTRACT

Background: Nurses are the touch point for different aspects of patient care, particularly in identifying early prodromal symptoms of acute myocardial infarction in women. Although there is increasing awareness of women-specific symptoms like fatigue, anxiety, and sleep disturbances, acute myocardial infarction is frequently underdiagnosed or recognized too late in women. Instruments such as the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey have demonstrated effectiveness in identifying these prodromal symptoms. However, no validated Italian tool exists to assess prodromal symptoms and predict myocardial infarction; developing one would help nurses detect symptoms early and improve outcomes in women.
Aim: The study aims to validate an Italian version of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey, and to evaluate the predictive ability of prodromal symptoms toward acute myocardial infarction in women, to secondarily test a potential cut-off score for easier implementation of the tool in screening contexts, and to identify prodromal symptom clusters in women with AMI.
Materials: A multicenter study was conducted from October 2023 to January 2025, including women with ischemic heart disease and healthy women. Both groups completed the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey, a structured questionnaire. Data analysis relied on test-re-test, regression models, and Receiver Operating Characteristic curve analysis to identify key prodromal symptoms of Acute Muocardial Infarction.
Results: The study involved 125 women with a mean age of 59.9 years. Women with acute myocardial infarction most commonly experienced chest pain, unusual fatigue, sleep disturbances, and anxiety. In contrast, healthy women reported fewer prodromal symptoms, with chest pain and unusual fatigue being less frequent. Reliability analysis showed excellent consistency in the tool (Cronbach's α $\geq$0.90), with strong test-retest correlations ($r = 0.973$, $p < 0.001$). Logistic regression identified significant chest symptoms and general ones associated with acute

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myocardial infarction. Receiver Operating Characteristic curve analysis indicated excellent discriminative ability, defining a cut-off score with high sensitivity and specificity.
Conclusions: Results showed different identifying symptoms such as chest, back, neck/throat, and left arm pain, fatigue, shortness of breath, loss of appetite, arm weakness, and headache. The results suggest that it can be used as an effective screening tool to identify women at risk of acute myocardial infarction.

What is already known

- Prodromal symptoms of acute myocardial infarction in women are often underrecognized, leading to delays in diagnosis and treatment.
- Existing literature highlights variability in prodromal symptom duration and presentation, with women frequently reporting atypical manifestations such as fatigue, anxiety, and sleep disturbance.
- Few validated instruments are available for assessing prodromal symptoms, and none have been validated in Italian populations.

What this paper adds

- Presents the first cross-cultural and linguistic validation of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey for use among Italian women.
- Identifies thoracic and general symptom clusters significantly associated with acute myocardial infarction and establishes a practical cut-off score (45) with high sensitivity and specificity, confirming the tool's predictive validity and clinical utility for early screening and nursing assessment.

1. Introduction

Cardiovascular disease is a leading cause of morbidity and mortality in women; however, it is often underdiagnosed, undertreated, and underrepresented in research studies focusing on the prevention, early detection, and therapeutic management of heart disease (Vogel et al., 2021).

Among the various forms of cardiovascular disease, ischemic heart disease has a higher prevalence and mortality, with approximately 197 million cases and 9.14 million deaths worldwide (Rodriguez et al., 2022). Although men account for 114 million cases, the risk of acute myocardial infarction is steadily increasing in women, with 83.6 million cases and 4.17 million deaths, showing a significant gender gap in prevalence and outcomes (Roth et al., 2020). Women are often treated late or underdiagnosed (Vogel et al., 2021). A particularly prominent aspect of ischaemic heart disease is Acute Coronary Syndrome, which includes ST-Elevation Myocardial Infarction, Non-ST Elevation Myocardial Infarction, and unstable angina, varying in severity and mode of clinical presentation (Singh et al., 2023).

In particular, recognition of prodromal symptoms, which occur before the onset of acute myocardial infarction, is critical for screening during healthcare visits, as it allows for early diagnosis, timely treatment and improved clinical outcomes (McSweeney et al, 2003).

Although attention to the prodromal symptoms of acute myocardial infarction dates back to the 1930s (Feil, 1937), they have not been studied extensively. Indeed, literature has primarily focused on the acute symptoms of myocardial infarction (McSweeney et al., 2003; King et al., 2007; Patel et al., 2004; Meischke et al., 1998; An et al., 2019; Dempsey et al., 1995). This underrepresentation is particularly relevant considering that these symptoms, generally regarded as warning signs of an impending acute coronary syndrome, are short-lived, less intense, and less specific than unstable angina (O'Keefe-McCarthy et al., 2016). They may occur hours, days, or weeks before the cardiac event but are transient and not always easily identifiable (O'Keefe-McCarthy & Ready, 2016). The duration of the prodromal syndrome, as reported in the literature, varies greatly, making it difficult to establish a specific range. The shortest interval between the onset of prodromal symptoms and definitive acute myocardial infarction reported in the literature was 14 hours, while the longest was two months (Solomon et al., 1969). Other studies have suggested that women may experience atypical prodromes for at least 1 month or more (up to 4–6 months) before their cardiac event (McSweeney et al., 2003; Soltani et al., 2021; Graham et al., 2008; Shi et al., 2020). Still other research, such as the study by Løvlien et al. (2009), has considered a prodromal period of up to 1 year.

Earlier study, such as Nixon and Bethell (1974), emphasized the importance of symptoms such as fatigue and pain as early signs of myocardial infarction but did not consider gender differences. Subsequently, more recent research has explored this in more depth, showing that women tend to have a broader range of prodromal symptoms than men (Sohail et al., 2023; Blakeman & Booker, 2016; Blakeman & Stapleton, 2018; Schulte et al., 2023; Cardeillac et al., 2022). For example, Hofgren et al. (1995) found that 70% of women reported symptoms before hospitalization, while McSweeney et al.'s (2000) evaluated 40 women with acute myocardial infarction and found that 92.5% of participants reported at least one prodromal symptom and 87.5% manifested symptoms three or more months before the event. The three main prodromal symptoms in women are: fatigue, present in up to 70% of cases (Albarran et al., 2007; Lindgren et al., 2008; Berg et al., 2009); anxiety, commonly reported in the weeks before the event (Miller et al., 2009; Smeijers et al., 2016); and sleep disturbance, associated with increased cardiovascular risk, particularly in those who sleep less than six hours per night (Chandola et al., 2010). Other less common symptoms include gastrointestinal symptoms, headache, cognitive changes, dyspnea, nervousness, palpitations, loss of appetite, and pain. Although these symptoms vary between studies, they are often ignored or attributed to causes unrelated to the patients themselves (Lichtman et al., 2015; Soltani et al., 2021). Some studies suggest that many women do not report prodromal chest pain in the days before the acute myocardial infarction, and when they do, they describe it as pressure, tightness, or discomfort (Albarran et al, 2007; Asghari et al, 2022).

Prodromal symptoms recognition is strictly and inversely related to delays in seeking and receiving care. Their severity and slow or intermittent onset contribute to delayed recognition of acute myocardial infarction risk, as women may not perceive themselves to be at risk (Rosenfeld, 2001; Kirchberger et al, 2011; Abed et al., 2015). The difficulty lies in recognising common prodromal symptoms and attributing them to anxiety or stress rather than to a heart problem (Bucley et al, 2007; Kirchberger et al, 2011) further jeopardize survivorship. This phenomenon affects not only patients but also healthcare professionals, or nurses, who often fail to respond to prodromal symptoms in a timely manner, negatively affecting the timing and effectiveness of interventions (Lichtman et al., 2015).

Nurses are in a privileged position to protect and educate patients so that they recognize the signs of acute myocardial infarction, encouraging them to pay attention and trust the signals coming from their bodies. Women should be encouraged to prioritize health and not to postpone medical visits for family or work reasons (Giordano et al., 2025), thus increasing their awareness and responsiveness and contributing to timely and targeted interventions (Yu et al., 2023; McDonald et al., 2006).

To examine the presence of symptoms, the Theory of Unpleasant Symptoms, developed by Lenz et al (1995), has been theorized to provide a useful framework for understanding the complexity of prodromal symptoms of acute myocardial infarction. According to this theory, symptoms arise from physiological, psychological, and situational factor that interact to influence the intensity, duration, and quality of symptoms.

The Theory of Unpleasant Symptoms highlights the synergistic interaction of symptoms through feedback mechanisms and their multidimensional nature influencing manifestation (Parker et al., 2005). Its application can improve symptom recognition and clinical outcomes, while studying prodromal symptoms of myocardial infarction helps assess psychological (e.g., anxiety) and situational (e.g., stress) factors affecting women's cardiovascular health (Lenz et al., 1997; Parker et al., 2005).

For the identification of prodromal symptoms, several tools have been developed to improve their recognition at an early stage, before the onset of overt clinical signs. Such tools play a crucial role in preventing disease progression and improving clinical data collection by nurses and healthcare professionals. Among the tools developed, the Prodromal Symptoms-Screening Scale, designed to identify prodromal symptoms in both men and women, has demonstrated a valid consistency (CVI, test-retest of 0.85) and a good internal consistency (Cronbach Alpha = 0.61) (O'Keefe-McCarthy et al., 2016). Another relevant tool is the Acute Coronary Syndrome Predictive Scale, which uses a 13-item scale with a score range from 0 to 130. Acute Coronary Syndrome provides a cut-off score of 11.5, with a sensitivity and specificity of 0.75 and a Cronbach's alpha coefficient of 0.80 (Elyaszadeh et al., 2024).

In line with the Updated Theory of Unpleasant Symptoms, the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey provides an operational translation of the model by capturing the multidimensional nature of symptoms. Rather than documenting isolated symptoms, MAPMISS systematically groups them into thoracic and general clusters, reflecting the interaction among physiological, psychological, and situational dimensions described by the theory. This conceptual alignment supports a structured analysis of prodromal symptoms in women and guides the development of targeted nursing interventions (Lenz et al., 1997; Parker et al., 2005).

The McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey, designed specifically for women, is a widely used instrument. Preliminary psychometric testing demonstrated good validity and reliability, with expert panel assessment further confirming its content validity (McSweeney et al., 2001, 2003, 2004, 2013, 2017). The robustness of its psychometric properties has supported its application in several studies within nursing literature (Wu et al., 2021; Graham et al., 2008). In addition, the longitudinal study conducted by McSweeney et al. (2017) using the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey suggests that prodromal symptoms such as fatigue and anxiety are significant indicators of coronary heart disease risk in women, thus demonstrating the ability of the tool to detect prodromal symptoms.

However, despite progress, there are still gaps in the understanding of prodromal symptoms and their measurement in women. Only one study by Milner et al., 2001, has investigated the relative risk associated with individual symptoms and attempted to develop predictive models of acute myocardial infarction risk. In this context, McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey could be a useful tool for healthcare professionals and nurses in the screening phase, improving the ability to predict cardiac risk and directing patients to more targeted treatments. Despite its potential, the practical application of this scale in routine clinical practice is limited. The development of advanced analytical models may allow the estimation of specific scores that can more accurately discriminate patients at risk, making the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey scale an effective ally in the early management of heart disease.

Therefore, the study aims to validate an Italian version of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey, to evaluate the predictive ability of prodromal symptoms toward acute myocardial infarction in women, to secondarily test a potential cut-off score for easier implementation of the tool in screening contexts, and to identify prodromal symptom clusters in women with acute myocardial infarction.

2. Materials and methods

2.1. Study design

A multicenter comparative observational study was conducted from October 2023 to January 2025 in the Cardiac Intensive Care Unit, Cardiology Units, and cardiology outpatient clinics of two Hospitals Located in the Campania Region, Southern Italy.

2.2. Partecipants

The study included a total of 125 women, of whom 73 were enrolled in the healthy group and 52 in the patient group (*Supplementary table 1*).

We did not know the outcome prevalence in the source population at the design stage; therefore, we reported a sensitivity (detectable-effect) power analysis rather than targeting a single prevalence. Using Hsieh's method for multiple logistic regression as implemented in GPower (two-sided $\alpha = .05$, $1-\beta = .80$), with standardized continuous predictors and moderate collinearity among covariates (assumed $R_{other}^2=.20$), the achieved sample size (N=125) yields 80% power to detect per-SD odds ratios (OR) of approximately 2.55, 2.02, 1.85, and 1.76 when the underlying outcome prevalence is $\pi=0.10$, 0.20, 0.30, and 0.50, respectively (Wald test). Thus, the study is powered to detect moderate-to-large effects over a wide range of plausible prevalences, but would be underpowered for small effects (e.g., OR $\leq$ 1.5). Calculations followed the Hsieh/Whittemore closed-form approximations and the GPower 3.1** implementation; model parsimony was maintained to preserve a reasonable events-per-parameter ratio as recommended in recent simulation studies (Hsieh, 1989; Whittemore, 1981; Faul et al., 2007; Faul et al., 2009; Hanley & McNeil, 1982; Vittinghoff & McCulloch, 2007).

Inclusion criteria for the patient group: (a) women between 20 and 85 years of age; (b) definitive diagnosis of ischaemic heart disease by a cardiologist; (c) favorable and stable physical condition for conducting interviews.

Inclusion criteria for the healthy group: (a) healthy in terms of cardiac health status (assessed by a cardiologist based on physical examination and diagnostic tests (electrocardiogram, echocardiogram, and ergometric test) and no incidence of ischaemic heart disease.

Exclusion criteria: Difficulty in speaking and understanding Italian and the presence of cognitive deterioration

2.3. Measures

1. *Questionnaire on socio-demographic variables* collects information on socio-demographic aspects such as date of birth, country of origin, nationality, period of residence in Italy, marital status, level of education, profession, household income and presence of other income earners.
2. *McSweeney Acute and Prodromal Myocardial Infarction Symptom* (McSweeney et al., 2001, 2003, 2004, 2013, 2017): is one of the most important instruments for identifying acute and prodromal symptoms of coronary heart disease and myocardial infarction in women. It consists of three parts:
   (a) *Acute symptoms*: administered after a cardiac event.
   (b) *Prodromal symptoms*: 30 questions administered to investigate symptoms that may precede an acute event but also when no event has occurred (e.g., in healthy women). This section is divided into two symptom clusters: chest symptoms (e.g., mid-chest pain and left chest pain); general symptoms (e.g., unusual fatigue, cough, anxiety). Prodromal symptoms are characterized by symptoms that are new or increase in intensity before the infarction, are intermittent before the event, and disappear or return to previous levels after the infarction. Women rate each of the reported PSs according to intensity (mild, moderate, or severe), frequency (e.g. less than once a month, monthly), and time of onset (e.g. within the last month, two months, or three months). A score is then calculated for total symptoms (total symptom score) and for each of these clusters (thoracic cluster score and general cluster score) based on the product of symptom intensity and frequency.
   (c) *Baseline section*: comorbidities, risk factors and medications.

In this study, the section on prodromal symptoms, as they represent the key elements for analyzing symptom clusters before the acute event. The decision to focus on these aspects stems from the objective of assessing the tool's ability to identify early predictive signals of acute myocardial infarction.Psychometric testing has shown that the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey has high content validity and acceptable test-retest reliability in women with known coronary heart disease (McSweeney et al., 2013). The reliability of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey as a screening tool has been demonstrated in Caucasian and African American women (test-retest reliability $r = 0.92$, $p < 0.001$; concordance correlation coefficient $= 0.92$, $p < 0.001$) (McSweeney et al., 2013, 2017). The content validity of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey was assessed by seven content experts during the development of the instrument (McSweeney et al., 2013). Only the symptom sections (thoracic symptom cluster and general symptom cluster) and the baseline section were used for this study. The instrument underwent the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey linguistic validation process according to the Beaton et al. model, which consisted of five steps: forward translation, synthesis, backward translation, expert committee review, and pretest. The questionnaire was translated by two native Italian translators, followed by the synthesis and backward translation by native English translator, according with the authors of the tool.

2.4. Procedure

The study followed the guidelines of Beaton et al. (2020) for the cross-cultural and linguistic validation of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey. After obtaining permission from the original authors, forward translation was conducted independently by two native Italian translators, followed by the synthesis of the versions and back-translation by two native English translators. A committee of seven experts (including cardiologists, specialized nurses, and women with direct experience) assessed clarity, relevance, and cultural equivalence. Finally, the pre-final version was tested on a sample of 10-15 women with acute myocardial infarction to verify its comprehensibility and cultural appropriateness, with minor revisions made where necessary.

In order to test the predictive validity of the scale, the study relies on two different groups, women with acute myocardial infarction enrolled at time 0 (T0) within 5 days of the acute event and healthy women enrolled at T0 during the cardiology outpatient visit. The questionnaire took 20-25 minutes to complete. In order to evaluate test-retest reliability of the scale, a random subset of women (n=34; healthy groups= 18; patient group=16) who completed the interview at T0 were asked about their willingness to be contacted 7-14 days after the first interview (T1) to complete the questionnaire again.

2.5. Analysis

Data was analyzed using both descriptive and inferential statistical techniques using Jamovi software version 2.6.23. Descriptive statistics were performed for socio-demographic characteristics and symptoms reported by the sample. In order to verify the normality of the distribution of the collected data skewness and kurtosis indices were evaluated. A cut-off value of ± 3 (Hae-Young, 2013) was considered. An alpha value of $p < 0.05$ was considered for this study, and statistically the effects were worthy of note with $p < 0.1$ given the sample size. In order to test the reliability of the scale, we performed a test-retest (Cronbach's alpha) on data collected in group 1 (n=18 healthy group; n=16 patient group; 7-14 days after the first interview as described in the procedure). To test the discriminant and predictive validity of the tools, two logistic regression models were tested: the first regressed the cluster of chest symptoms (independent variables) on the presence or absence of infarction; the second regressed the cluster of general symptoms on the same dependent variable (i.e., presence or absence of infarction). Finally, in line to test the discriminant and predictive validity of the scale, a receiver operating characteristic (ROC) analysis was performed using the symptom total score as a discriminator variable for incidence or infarct event. The Receiver operating characteristic relates sensitivity (proportion of true positives) and specificity (proportion of true negatives) at different thresholds. Specifically, the area under the curve (AUC) is an overall measure of the model's ability to discriminate, with values ranging from 0.5 to 1. An AUC close to 1 indicates that the model has an excellent ability to discriminate between classes, while an AUC close to 0.5 indicates that the model has a performance like that of a random decision.

3. Results

3.1. Sociodemographic and clinical characteristics of the sample

The study included 125 women with a mean age of 59.9 ± 17.7 years. Most of the participants were married (63.2%), while 18.4% were widowed; occupationally, 44% of the women were housewives, followed by pensioner women (25.6%), while a smaller percentage were employed (12.8%) or workers (7.2%). In terms of education, 29.6% of the women had attended secondary school, 24.8% primary school and 18.4% upper secondary school. Only a small percentage had a bachelor's degree (2.4%) or a master's degree (12%). At the economic level, 94.4% of the women had an annual income of less than 30,000 euros, with 76% of them being highly economically dependent on third parties. Analysis of comorbidities shows a predominance of hypertension (60%), followed by hypercholesterolemia (47.2%), chronic back pain (42.4%), stomach problems (40.8%), and thyroid disease (38.4%). In addition, 25% of the participants were diabetic or had blood sugar problems, while 16% had a history of angina. Among the risk factors, 40.3% of women have never smoked, while 30.6% currently smoke. In this sample, 25.6% of women have a Body Mass Index greater than 24.9, 76.6% are menopausal at an average age of 49.6 years, and only 19.2 % have taken hormone therapy in the past or currently. Physical activity is practiced by 98.4% of the sample, but with a clear preference for light activities such as housework (85.5%) and walking (32.3%). Finally, access to cardiac care is limited, with only 20% of participants having visited a cardiologist in the last three months.

For more details on the characteristics of the overall sample and subgroups, see in *Supplementary File*.

3.2. Chest symptom clusters and general symptom clusters in women

Women with acute myocardial infarction most frequently present with thoracic symptom clusters such as chest pain, particularly in the center hight of the chest (78.8%), and generalized symptom clusters such as unusual fatigue (75%) and sleep disturbances (65.4%). Anxiety (50%) and shortness of breath (48.1%) are also common symptoms. Other symptoms found are increased intensity of headache (30.8%), changes in thinking and memory (30.8%), pain and weakness in the arms (44.2%), indigestion (32.7%), loss of appetite (26.9%) and heart racing (42.3%). In healthy women, prodromal symptoms are less frequent than in women with acute myocardial infarction. The thoracic symptom cluster is rare, with pain in the center of the chest in 11% of cases and pain throughout the chest in only 2.7%. Other symptoms involve the generalized symptom cluster, such as accelerated heartbeat (17.8%), new onset of vision problems (4.1%), anxiety (6.8%), unusual fatigue (6.8%), sleep disorders (4.1%), and increased intensity (2.7%) or frequency of headache (4.1%) are present but less common. The data were evaluated, and normality was confirmed for the described cuf-offs ± 3 (Hae-Young, 2013). This first data set clearly shows the difference in the frequency of prodromal symptoms between women who have had an acute myocardial infarction and healthy women.

For more details on the frequency of thoracic and general acute myocardial infarction symptom clusters are given in Table 1.

Among the cluster of thoracic symptoms reported only by women with acute myocardial infarction, in the subset at 7–14 days after the event (patient group, n=16), 75% reported pain in the center hight of chest, 25% pain throughout the chest, 43.8% left breast, 25% pain in the neck or throat, 12.5% pain in the jaw or teeth, 25% pain in the back between 31.3% pain in the upper shoulders. Pain in the arms was common, with 56.3% reporting pain in the left arm and 43.7% in the right: 12.5% reported pain in the legs. The most common general symptom clusters included marked unusual fatigue (75%), sleep disturbances (81.2%) and anxiety (62.5%). On the cardiopulmonary side, patients reported coughing (37.5%), heart racing (50%), shortness of breath (56.3%) and difficulty breathing at night (25%%). Gastrointestinal symptoms included loss of appetite (18.7%) and frequent indigestion (37.5%). Abnormal sensations in the limbs included weakness/heaviness in the arms or pain (43.8%), tingling in the arm (37.5%), numbness or burning in the arms (25% in the right arm and 37.5% in the left) and in the fingers of the hands (18.8% in the right and 25% in the left). Finally, neurological symptoms included new visual problems (18.8%), increased intensity (18.8%) and frequency of headaches (6.2%), as well as cognitive changes such as difficulties in thinking or memory (43.8%). This second paragraph does not make a comparison with healthy women but describes in depth the symptomatic experience of women who have had an acute myocardial infarction, highlighting the complexity and variety of prodromal symptoms.

For more details on the frequency of thoracic and general acute myocardial infarction symptom clusters in healthy woman or patient woman are given in Table 1.

Table 1
Frequency of thoracic symptom clusters and general symptom clusters of AMI.

	Baseline			After 7-14 days		
	Total cases with symptoms (n) (n=125)	Healthy Group (n=73)	Patient Group (n=52)	Total cases with symptoms (n=34)[a]	Healthy Group (n=18)[a]	Patient Group (n=16)[a]
Prodromal Symptoms						
Chest Symptoms						
Pain throughout the chest	20	2 (2.7%)	18 (34.6%)	4	—	4 (25%)
Pain in the center high of chest	49	8 (11%)	41 (78.8%)	12	—	12 (75%)
Left breast pain	20	2 (2.7%)	18 (34.6%)	7	—	7 (43.8%)
Neck/Throat Pain	20	1 (1.4%)	19 (36.5%)	4	—	4 (25%)
Jaw/teeth pain	10	1 (1.4%)	9 (17.3%)	2	—	2 (12.5%)
Back pain, between/under the shoulder blades	24	1 (1.4%)	23 (44.2%)	4	—	4 (25%)
Upper shoulder pain	19	2 (2.7%)	17 (32.6%)	5	—	5 (31.3%)
Arm pain-right	19	3 (4.1%)	16 (30.8%)	7	—	7 (43.8%)
Arm pain-left	25	3 (4.1%)	22 (42.3%)	9	—	9 (56.3%)
Leg Pain	10	—	10 (19.2%)	2	—	2 (12.5%)
Generalized symptoms						
Very tired/unusual fatigue	44	5 (6.8%)	39 (75%)	12	2 (11.1%)	12 (75%)
Sleep disorders	37	3 (4.1%)	34 (65.4%)	13	—	13 (81.2%)
Anxiety	31	5 (6.8%)	26 (50%)	10	—	10 (62.5%)
Heart and lung symptoms						
Cough	15	3 (4.1%)	12 (23.1%)	6	—	6 (37.5%)
Heart racing	35	13 (17.8%)	22 (42.3%)	8	2 (11.1%)	8 (50%)
Shortness of breath	29	4 (5.5%)	25 (48.1%)	9	1 (5.6%)	9 (56.3%)
Difficulty breathing during the night	11	2 (2.7%)	9 (17.3%)	4	—	4 (25%)
Gastrointestinal symptoms						
Loss of appetite	16	2 (2.7%)	14 (26.9%.)	3	—	3(18.7%)
Frequent indigestion	19	2 (2.7%)	17 (32.7%)	6	—	6 (37.5%)
Sensation in arms						
Weak/heavy arms	24	1 (1.4%)	23 (44.2%)	7	—	7 (43.8%)
Pain in the arms	25	2 (2.7%)	23 (44.2%)	7	—	7 (43.8%)
Tingling in the arms		—	9 (17.6%)	6	—	6 (37.5%)
Numbness or burning in arms-right	10	—	10 (19.2%)	4	—	4 (25%)
Numbness or burning in arms-left	12	—	12 (23.1%)	6		6 (37.5%)
Numbness, tingling or burning of hands/fingers-right	7	—	7 (13.4%)	3	—	3 (18.8%)
Numbness, tingling or burning of hands/fingers-left	9	—	9 (17.6%)	4		4 (25%)
Neurological symptoms						
New onset of vision problem	12	3 (4.1%)	9 (17.6%)	3	2 (11.1%)	3 (18.7%)
Increased intensity of headache	18	2 (2.7%)	16 (30.8%)	3	1 (5.56%)	3 (18.7%)
Increased frequency of headache	16	3 (4.1%)	13 (25.5%)	1	—	1 (6.2%)
Change in thinking or remembering	19	3 (4.1%)	16 (30.8%)	7	—	7 (43.8%)

Note.
[a] =subset after 7-14 days; percentages calculated on the total of the respective group (Healthy n=73, Patient n=52 at baseline; Healthy n=18, Patient n=16 after 7-14 days)

3.3. Reliability and test-retest

Reliability was considered 'excellent' for values of Cronbach's α ≥0.90, 'good' for α between 0.90 and 0.80, and 'acceptable' for α between 0.80 and 0.70 (Kline, 2013). To assess the test-retest reliability of the measures, Pearson's correlation coefficient (r) was used, comparing the scores obtained at two different times (T0 and T1). The results show strong correlations between the measurements taken at T0 and T1, suggesting that all the variables analyzed are reliable. For example, the total symptom score at T0 showed a high correlation with the same variable at T1 ($r = 0.973$, $p < .001$); the total symptom score at T0 showed a strong correlation with the same score at T1 ($r = 0.847$, $p < .001$) and the symptom score at T0 showed a very high correlation with the same score at T1 ($r = 0.976$, $p < .001$), indicating a remarkable stability of the measure over time.

3.4. Logistic regressions

3.4.1. Chest symptoms cluster

A logistic regression analysis was performed using all symptoms (independent variable) on the infarct event (dependent variable, "event"), controlling for variables (age, Body Mass Index, marital status) to ensure model parsimony, statistically insignificant symptoms were eliminated, resulting in the following "parsimonious model". The regression model explains a total R^2McFadden variance of 0.747. In addition, the results showed the following symptoms to be statistically significant for the heart attack event: mid-chest pain, back pain, neck/throat pain and left arm pain. Of course, the variable left chest pain showed a trend close to significance (p=.066). See *Table 2* for effect estimates and significant levels.

3.4.2. General symptom clusters

A logistic regression analysis was performed using all symptoms (independent variable) on the myocardial infarction event (dependent variable, "event"), controlling for variables (age, Body Mass Index, marital status) to ensure model parsimony, statistically insignificant symptoms were eliminated, resulting in the following "parsimonious model". The regression model explains a total R^2McFadden variance of 0.715. In addition, the results showed the following symptoms to be statistically significant for the heart attack event: unusual fatigue, shortness of breath, loss of appetite, weak arms, severe headache. See *Table 2* for effect estimates and significance levels Table 3.

3.4.3. Receiver Operating Characteristic (ROC)

Analysis of the Receiver Operating Characteristic curve (Figure *1*) showed a high discriminative ability of the model. The area under the curve (AUC = 0.979; 95% CI: 0.959 - 0.999; p < 0.001) indicates excellent accuracy in discriminating between the two groups analyzed. The optimal cut-off value was 45, corresponding to a sensitivity of 97.3% and a specificity of 92.3%, providing a good balance between correctly identifying true positives and minimizing false positives. In addition, the positive predictive value (PPV) is 94.7%, while the negative predictive value (NPV) reaches 96.0%, confirming the reliability of the model in correctly classifying subjects. The model demonstrates excellent discriminative ability in distinguishing women with acute myocardial infarction from those without the condition.

4. Discussion

In our study, we found that women with acute myocardial infarction had clusters of chest symptoms, such as pain in the center of the chest, and clusters of general symptoms, such as unusual fatigue, sleep disturbance, anxiety, and shortness of breath, compared with healthy women. These symptoms are consistent with the study by McSweeney et al., 2014, who report general chest discomfort, shortness of breath, and unusual fatigue as the most common symptoms in women with acute myocardial infarction compared to healthy women. Our results also report symptoms such as increased headache, impaired thinking and memory, pain and weakness in the arms, indigestion, and loss of appetite. In contrast, prodromal symptoms were less common in healthy women, with a low incidence of chest symptoms and a moderate incidence of general symptoms such as anxiety, heartbeat, and visual disturbances, intensity and frequency of headache, and sleep disturbances.

Although women without chest pain at presentation with acute myocardial infarction reported fewer symptoms than those with chest pain, most of these patients still reported at least one symptom other than chest pain. Therefore, relying on the presence of chest

Table 2
Logistic regression of the thoracic symptom cluster.

Predictor	Stime	Standard Error	Z	*p*
Intercept	3.620	0.6948	5.21	<.001
Pain in the center high of chest	-0.308	0.0832	-3.70	<.001
Back pain	-1.228	0.5553	-2.21	.027
Left breast pain	-0.167	0.0911	-1.84	.066
Neck/throat pain	-0.470	0.2157	-2.18	.029
Pain in left arm	-2.088	0.5852	-3.57	<.001

Note. Estimates represent logarithmic probabilities of '... = {level 1}' versus 'GROUP = {level 2}'
Z= test statistic; p= probability value.

Table 3
Logistic regression of the general symptom cluster.

Predictor	Stime	Standard Error	Z	*p*
Intercept	3.203	0.5844	5.48	<.001
Unusual fatigue	-0.308	0.0690	-4.46	<.001
Shortness of breath	-0.127	0.0681	-1.87	0.062
Loss appetite	-0.327	0.1591	-2.06	0.040
Weak/ heavy arms	-0.571	0.2700	-2.11	0.035
Increased intensity of headaches	-0.169	0.0603	-2.80	0.005

Note. Estimates represent logarithmic probabilities of '... = {level 1}' versus 'GROUP = {level 2}'
z= test statistic; p= probability value.

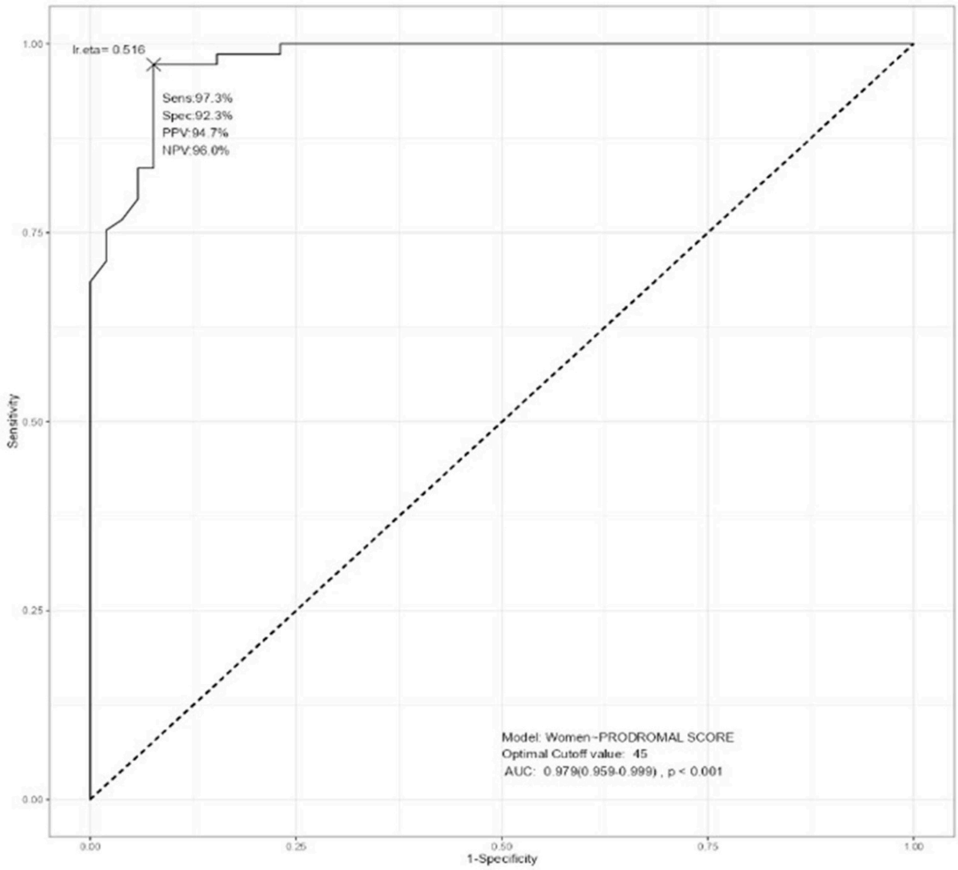

Fig. 1. Receiver–operator characteristic (ROC) curve of for predicting infarct event. Sensitivity is plotted against specificity, with optimal cut-off: 45; AUC = 0.97.

pain alone may further contribute to the underdiagnosis of acute myocardial infarction. We also observed that some symptoms, such as chest pain and fatigue, were common both in the comparison between women with acute myocardial infarction and healthy women and within the group of women with acute myocardial infarction. In our study, chest pain was the most frequently reported prodromal symptom, affecting 78.8% of the women with acute myocardial infarction. This prevalence was higher than that described by Khan et al. (2017) and McSweeney et al. (2003), comparable to the findings of O'Keefe-McCarthy et al. (2016), and lower than those reported by Løvlien et al. (2006). These differences reflect the variability observed in literature, which may be due to differences in study populations, methodologies, or in how prodromal symptoms were defined. Overall, our result falls within the wide range reported (23.6%–90%). This suggests that these symptoms are not only useful signals to discriminate the presence of disease from the healthy population but are also the most common clinical manifestations in women with acute myocardial infarction. Their high prevalence may reflect pathophysiological mechanisms common to most female myocardial ischaemic presentations, making them potential targets for more targeted diagnostic and educational strategies. Consistent with other studies, our findings also suggest that women were more likely to experience symptoms such as anxiety, sleep disturbance, and dyspnoea, which were reported with higher prevalence (McSweeney et al, 2003; Joseph et al., 2021; Khan et al., 2017; O'Keefe-McCarthy et al., 2016), as well as headache, cognitive changes, indigestion, and loss of appetite (Graham et al., 2008; Khan et al., 2017; O'Keefe-McCarthy et al., 2016). In our study, conducted in healthy women and women with acute myocardial infarction, the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey instrument showed high test-retest reliability, with a Pearson correlation of $r = 0.973$ ($p < 0.001$) between scores obtained at T0 and T1. These results are consistent with those of McSweeney et al. (2013), who documented excellent test-retest reliability for the prodromal symptom score ($r = 0.92$), even in women with no history of cardiovascular disease who were screened. Compared with a previous study by McSweeney et al. (2004), in which the test-retest correlation of the prodromal symptom score was $r = .72$ ($p < 0.01$), the results of our study show a higher correlation, suggesting greater consistency in the responses provided by participants over time. Furthermore, our instrument has been shown to have higher reliability compared to other screening instruments available in the literature, such as the Prodromal Symptoms Screening Scale (CVI of 0.85 and internal consistency of 0.61 (O'Keefe-McCarthy et al., 2016) or the Acute Coronary Syndrome – Predictive Scale, which has a sensitivity and specificity of 0.75 and a Cronbach's alpha coefficient of 0.80 (Elyaszadeh et al., 2024). As the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey score is based on women's self-report of the number, intensity, and frequency of perceived symptoms, the reliability of responses over time is crucial.

Our regression model explained 74% of the variance for chest symptoms and 71% for general symptoms. The most significant thoracic symptom clusters were pain in the center of the chest, pain in the back, neck/throat, left arm, and left chest. For the general symptom cluster, the most significant were unusual fatigue, shortness of breath, loss of appetite, weakness/heaviness in the upper limbs, and increased headache intensity. Our results are consistent with those of Heidarzadeh et al (2021), who identified symptoms such as weakness/heaviness in the arms, nocturnal dyspnea, neck/throat pain/discomfort, chest pain, loss of appetite, and unusual fatigue as signs strongly associated with acute myocardial infarction in both men and women. Our results are consistent with those of Shi et al. (2020), who found, using adjusted logistic regression models, that back pain was a commonly reported symptom, while loss of appetite was more common in men than in women. However, some of our findings differ from those reported by McSweeney et al. (2017), who found no significant correlations between prodromal symptoms and acute myocardial infarction, whereas in our study symptoms such as chest pain, back pain, neck/throat pain, left arm pain, unusual fatigue, shortness of breath and loss of appetite were found to be strongly associated with the occurrence of acute myocardial infarction. Analysis of the relationship between prodromal symptoms, age, Body Mass Index, and marital status in our study showed no statistically significant associations. This finding is consistent with the observations of McSweeney et al (2001), who examined the relationship between prodromal symptoms and specific factors/comorbidities in patients with acute symptoms and found no significant associations. This lack of significance may be due to the small sample size and the large number of variables analyzed. In our study, an association was found between prodromal symptoms (such as chest pain, unusual fatigue, and shortness of breath) and the incidence of acute myocardial infarction. However, due to the observational nature of the study means that we cannot establish a cause-and-effect relationship. Other factors, such as comorbidities and lifestyle, may influence these symptoms (Mosca et al., 2011). However, it is increasingly recognized that women often experience different or additional symptoms to the classic chest pain. This study is the first in Italy to identify specific prodromal symptoms that may predict future cardiac events, offering an important opportunity for intervention for both physicians and women themselves.

Further longitudinal studies are needed to find out whether these symptoms predict acute myocardial infarction or are just indicators of risk. Furthermore, the patterns of relationship between symptoms and acute myocardial infarction observed in the study are consistent with those reported in other previous studies (Heidarzadeh et al., 2021; Shi et al., 2020; McSweeney et al., 2017). This consistency suggests that the scale used to assess symptoms might have predictive validity, i.e., be a reliable tool for early identification of heart attack risk.

Our Receiver operating characteristic curve showed that the tool has great potential as a screening tool that is easy to administer and can be used in a variety of clinical settings to effectively and reliably monitor the severity and frequency of symptoms in women at risk for acute myocardial infarction. The tool can be used to estimate a risk index, an approach that is particularly useful in outpatient settings, where speed of assessment is essential. In previous studies, the authors did not determine the sensitivity, specificity or cut-off point for any of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey or Prodromal Symptoms -Screening Scale (McSweeney et al., 2004; O'Keefe-McCarthy & Guo, 2016); only the Acute Coronary Syndrome-Predictive scale by Elyaszadeh et al., 2024, showed adequate sensitivity and specificity as a predictive tool, demonstrating a good ability to distinguish between low- and high-risk individuals. However, its cut-off point proved to be less precise than the results obtained in our study. Therefore, our model appears more reliable and precise in discriminating against at-risk individuals, offering greater accuracy than the other instruments.

Currently, healthcare providers are often faced with the need to use expensive and invasive diagnostic tools such as echocardiograms, stress tests, angiograms and Coronary Computed Tomography scans to assess the risk of coronary heart disease (McSweeney et al., 2013). However, to date no study has applied the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey methodology in the Italian context, in particular specific indices and cut-offs, and most international research has focused on the risk index in different ways (Milner et al., 2002).A rapid test with a cut-off of 45 could be easily implemented in Italian healthcare facilities and quickly identify patients at risk, especially in settings with limited access to advanced technologies. The literature, such as the study by Giordano et al. (2025) and Gallagher et al. (2010), highlights that women did not receive timely assessment or formal diagnosis even when symptoms clearly indicated acute myocardial infarction, and that health care providers, particularly nurses, struggled. Integrating symptom screening tools into triage could help nurses quickly identify patients at cardiovascular risk (O'Donnel et al., 2012) by assigning more accurate scores than the generally low triage scores (Atzeman et al, 2009). This would improve cardiovascular risk management, reduce waiting times and increase the effectiveness of triage. This tool could be extended beyond the hospital setting to include community emergency services, general practice, pharmacies and telemedicine, and improve the care activities, preventive and educational interventions provided by nurses. Use within the emergency system would allow nurses, who are faced with identifying patients at high risk of acute myocardial infarction at first contact, triggering an emergency protocol with immediate electrocardiogram and prioritization to the if necessary, reducing the risk of underestimating severity. This tool, if used in conjunction with other artificial intelligence and machine learning tools, cross-referencing the scores with other clinical and medical history parameters, could enhance its predictive ability and improve diagnostic accuracy to recognize cardiac symptoms. Its use could also have benefits in the home setting, allowing patients to complete the test at home and send it to clinicians, optimizing the selection of patients for the emergency department and reducing inappropriate admissions; and in post-infarction follow-up to monitor symptoms and detect early signs of recurrence, allowing a personalized treatment approach that adapts to the patient's clinical evolution. In particular, this tool could be used by nurses during cardiac rehabilitation, a crucial phase in post-infarction recovery (Calvo-Lopez et al., 2023). Its ability to identify unusual symptoms at an early stage would allow targeted and personalized interventions to be implemented, considering the different needs and behaviors of patients, who show variability in their ability to self-manage coronary artery disease (Yang et al., 2025). Therefore, the Italian version of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey showed high reliability and validity, supporting its clinical use in the early screening of women at risk of acute myocardial infarction.

4.1. Limitations

The study has several limitations. Firstly, it must be emphasized that one of the main limitations is the small sample size, but this limitation must be put into context, given the difficulties in recruiting participants for convenience, as the estimated population of women with myocardial infarction in the Campania region is unknown. Despite the limitations, the data collected provide useful insights for future research, which could involve larger samples and a more precise definition of the population. The short interval (7-14 days) between the first test and the test-retest could affect the stability of the measurements, but as the score is based on symptoms reported in the previous 12 weeks, symptoms would be expected to remain stable unless significant changes occur; a longer interval could reduce recall bias but increase the risk of variation in actual symptoms (McSweeney et al., 2013). Another limitation of the study is that the analysis included only women; therefore, future studies should assess the applicability of the instrument as well as potential differences in the male population. Despite the limitations of the study, the results confirm the reliability and validity of the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey score for prodromal symptoms and highlight its usefulness as a screening, monitoring, and clinical assessment tool in women with acute myocardial infarction.

4.2. Implications for clinical practice

The decision to conduct the study in women only was based on evidence that the symptoms of acute myocardial infarction are different in women than in men, with symptoms being less common and often unrecognized by healthcare providers, increasing the risk of delayed or misdiagnosis and leading to nuanced symptoms often being overlooked.

This disparity made a study of symptoms in women essential to bridge the gap and develop a targeted screening tool that could be integrated into daily clinical practice to improve the timeliness of diagnosis and appropriateness of care. delaying crucial diagnoses such as acute myocardial infarction.

To further optimize the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey tool, it would be useful to develop specific versions for different age groups, for diabetic patients or those with a history of previous heart attacks, and to test its applicability in the male population as well. Further enhancement could come from integrating McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey with advanced biomarkers, such as ultrasensitive troponin or C-reactive protein, in order to improve its predictive ability and reduce the need for invasive testing. However, to confirm the efficacy and reliability of McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey on a large scale, it is essential to conduct studies on larger samples that can validate its predictive efficacy and applicability in various clinical settings. Future studies should include longitudinal studies to monitor the evolution of cardiovascular risk over time to further validate the predictive ability of McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey over longer periods of time. The design of such studies would allow a better understanding of factors, such as comorbidities or changes in treatment, that may influence long-term predictive outcomes. Other studies could investigate cross-cultural differences. Populations from different geographical regions or with different socio-cultural backgrounds may respond differently to the same cardiovascular risk factors, affecting the relevance and effectiveness of McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey. Factors such as diet, lifestyle and genetic predisposition may vary considerably between cultures and these differences could affect the predictive value of the tool. Therefore, it is essential to conduct studies in diverse populations to test the performance of McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey in heterogeneous clinical settings, including men, to ensure an accurate assessment of its applicability on a national scale.

5. Conclusion

The tool showed high reliability in predicting heart attack risk, identifying symptoms such as chest, back, neck/throat, and left arm pain, fatigue, shortness of breath, loss of appetite, arm weakness, and headache as significant factors. The results suggest that the McSweeney Acute and Prodromal Myocardial Infarction Symptom Survey can be used as an effective screening tool to identify women at risk of acute myocardial infarction at an early stage, thereby optimizing early diagnosis and management of patients at risk. The use of such a screening tool could optimize early diagnosis, allowing early intervention and targeted management of patients at risk, thereby reducing the likelihood of adverse outcomes.

Ethics statement

The study was approved by the Campania 3 Ethics Committee (Protocol No. 151) on 5 June 2023. The study was conducted in accordance with the tenets of the Declaration of Helsinki. The ethical principles of informed consent, voluntary participation, the right to withdraw, confidentiality and anonymity were observed. All participants were informed about the nature and objectives of the study and were given the opportunity to withdraw at any time during the data collection phase.

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CRediT authorship contribution statement

Vincenza Giordano: Writing – review & editing, Writing – original draft, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Teresa Rea:** Writing – review & editing, Conceptualization. **Andrea Chirico:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Gianluigi Comparone:** Conceptualization. **Luigi Chianese:** Writing – review & editing. **Plinio Cirillo:** Writing – review & editing, Methodology, Data curation, Conceptualization. **Assunta Guillari:** Writing – original draft, Validation, Methodology, Investigation, Data curation, Conceptualization.

Declaration of competing interest

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.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijnsa.2025.100473.

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