BMC Nursing

RESEARCH

Open Access

Building nursing leaders: the influence of entrepreneurial leadership program on nurse interns' innovation and clinical performance

Manal Saleh Moustafa Saleh[1,2*], Azza Abdeldayem Ata[2], Zaineb Naiem Abd-Elhamid[2], Ashraf Amin Eltahan[2,3], Hamad Ghaleb Dailah[4] and Hanan Elsaid Elsabahy[5*]

Abstract

Background Leadership is essential for nursing to provide high-quality treatment, productive cooperation, and flexible responses to the always-developing healthcare environment. In nursing educational programs, entrepreneurial leadership places a strong emphasis on cultivating qualities that promote creative problem-solving and inventive thinking. These abilities can be employed in clinical settings to enhance patient care, leadership, innovation, and healthcare delivery. Social learning theory describes how these skills are acquired through learning, imitation, observation, and reinforcement.

Aim to investigate the effect of the entrepreneurial leadership intervention program on nurse interns' work innovation and overall performance in the clinical setting.

Methods A two-arm, parallel, open-label randomized controlled trial was conducted at Mansoura University Hospital, Governorate, Egypt. 1026 nurse interns were included in the study. Random assignment was used to place nurse interns in either the study group ($n=513$) or the control group ($n=513$) by using the Entrepreneurship Knowledge Questionnaire, Entrepreneurial Leadership Behavior Questionnaire, the Work Innovation Questionnaire, Observation Checklist of Nurses Performance, and Demographic Information Form.

Result There were statistically significant differences between the study and control groups in total entrepreneurial knowledge, total entrepreneurial behavior, total work innovation, total performance, and all their dimensions, particularly at the immediate post-intervention and follow-up stages, with p-values of 0.000. The study group demonstrated highly significant improvements in entrepreneurial knowledge, total entrepreneurial behavior, total work innovation, total performance, and all their dimensions, particularly at the immediate post-intervention and follow-up stages, with p-values of 0.000.

*Correspondence:
Manal Saleh Moustafa Saleh
ms_salh@zu.edu.eg
Hanan Elsaid Elsabahy
Hanan_elsabahy@mans.edu.eg; hnanalsbahy20@gmail.com

Full list of author information is available at the end of the article

Conclusion This study demonstrates the significant impact of a structured entrepreneurial educational program on enhancing entrepreneurial behavior, work innovation, and performance among nurse interns. The intervention led to substantial and sustained improvements in various professional competencies, with the study group consistently outperforming the control group. These results emphasize the importance of targeted leadership development programs in fostering critical skills and promoting long-term knowledge retention and practical application.

Clinical trial number Not applicable.

Keywords Internship, Entrepreneurial leadership behavior, Work innovation, Nurse interns' performance

Background

Nurse interns in the healthcare sector face challenges related to performance, creativity, and entrepreneurial leadership. Due to limited experience and rigid organizational structures, they often struggle to balance clinical duties with innovation. Additionally, the fast-paced nature of the industry makes it difficult for interns to focus on performance metrics. To navigate these challenges, nurse interns should adopt a mindset of continuous improvement and seek mentorship opportunities that foster entrepreneurial thinking [1].

Entrepreneurial leadership in the healthcare sector is crucial for achieving corporate objectives and maintaining a competitive advantage. It encourages staff members to reach their full potential and recognizes entrepreneurial possibilities. Healthcare organizations should focus on creating positive leaders who help nurses advance their careers, improve innovative behavior, and increase production. Entrepreneurial leaders generate new ideas and support staff in overcoming obstacles and completing challenging jobs [2].

To serve society, entrepreneurial leadership in health care organizations is characterized as "the tracking of opportunities that are reacting fast and positively to rapid change and innovation" For nurse leaders in particular, an entrepreneurial leadership style is crucial because it helps them handle challenges and crises in the health care system and enhances the creative behavior of staff nurses. Innovation will, therefore, improve nurse interns' clinical practices and performance [3].

Innovation in nursing practice is significantly influenced by a combination of technical, social, political, and economic factors. Politically, healthcare laws and regulations shape nursing practices by encouraging the adoption of advanced techniques to meet legal requirements and improve patient outcomes. Financial support for healthcare initiatives can either facilitate or hinder innovation; for instance, investments in technology can enhance nursing efficiency and patient care, whereas budget constraints may restrict access to necessary resources. Additionally, the evolving demographics of patient populations require nurses to implement creative approaches that address diverse health needs and promote a patient-centered care model. From a technical perspective, advancements in medical technology and information systems enable nurses to apply evidence-based practices, streamline workflows, and enhance communication within healthcare teams. Together, these factors create a dynamic environment that drives nursing innovation, ultimately leading to improved patient satisfaction and more effective healthcare delivery [4].

Nurse interns play a crucial role in healthcare innovation by enhancing psychological capital, which includes optimism, resilience, hope, and self-efficacy. These qualities enable creative behaviors and valuable contributions to teams. Supportive spaces like medical makerspaces promote nurse-led innovations, and healthcare organizations can improve performance by funding educational initiatives and establishing innovative ecosystems [5].

Extensive research has explored the factors influencing nursing performance, which plays a vital role in delivering high-quality healthcare. A systematic review highlights that strong nursing leadership significantly enhances performance by fostering motivation through supportive behaviors and a positive work environment [6]. Additionally, studies indicate that an effectively managed performance evaluation system can improve job satisfaction among nurses, ultimately leading to better patient outcomes [7]. Moreover, existing literature emphasizes the detrimental impact of understaffing and poor working conditions, which create a cycle of decreased performance and higher turnover rates. These findings underscore the importance of addressing organizational structures and leadership strategies to optimize nursing performance and ensure excellent patient care [8].

The entrepreneurial leadership program for nurse interns is designed to foster innovation and creativity in the healthcare sector. This program improves problem-solving skills, encourages innovative thinking, and promotes proactive patient care. It enhances career prospects, patient outcomes, and system efficiencies. Integrating entrepreneurial principles into nursing education fosters a culture of innovation, preparing a new generation of healthcare leaders, fostering interdisciplinary cooperation and experiential learning, and ultimately improving performance and job satisfaction. Entrepreneurial leadership enhances team creativity among

nurses, creating an innovative healthcare environment. This creativity is facilitated by information exchange and team psychological safety, thereby improving nursing interns' performance by encouraging proactive behaviors and adaptability to changing healthcare demands [9].

Theoretical framework

To promote organizational success, leaders who innovate, take measured risks, and proactively spot possibilities are the focus of entrepreneurial leadership theory, which blends leadership with entrepreneurial ideas. Entrepreneurial leaders in the nursing industry inspire nursing interns to apply innovative solutions to healthcare problems and think creatively. In addition to improving patient care, this strategy encourages a culture of adaptation and ongoing development in therapeutic environments. Entrepreneurial leadership is essential for economic growth and entails leaders who innovate and take measured risks to propel corporate success [10].

When creating interventions meant to improve entrepreneurial behavior, transformational leadership and self-efficacy theory are essential components. By creating an atmosphere that rewards creativity and taking risks, transformational leadership, which is distinguished by its capacity to uplift and encourage followers, has a direct impact on the entrepreneurial attitude. The intrinsic motivation and self-efficacy of followers can be greatly increased by leaders who demonstrate transformational traits, including idealized influence, inspirational motivation, intellectual stimulation, and personalized consideration. This is especially crucial in entrepreneurial settings, where people frequently deal with uncertainty and difficulties. Transformational leaders may assist budding entrepreneurs in gaining the perseverance and dedication required to pursue their endeavors by fostering confidence and a common vision, which will ultimately result in increased performance and decreased burnout [11–13].

However, a key factor in determining entrepreneurial activity is self-efficacy theory, which highlights a person's confidence in their capacity to achieve in particular circumstances. Increased perseverance, risk-taking, and a proactive attitude to problem-solving are all characteristics of successful entrepreneurs that can be attributed to high self-efficacy. Self-efficacy-boosting interventions, such as training sessions, mentorship programs, and feedback systems, can encourage individuals to take charge and be creative. Organizations can develop customized programs that not only increase skills but also strengthen self-belief by incorporating self-efficacy theory into intervention design. This improves overall entrepreneurial outcomes [12, 14].

Through the lens of Social Cognitive Theory (SCT), which emphasizes the interaction between personal agency, environmental factors, and observational learning, the entrepreneurial leadership program for nursing interns can be better understood. Mentorship, a core component of the program, fosters an environment where trainees observe and emulate the proactive behaviors of experienced nurses, enhancing their creativity and clinical effectiveness. Beyond reinforcing knowledge through direct interaction and feedback, mentorship empowers interns to become proactive professionals by equipping them with the skills to overcome challenges and seize opportunities in their clinical settings [15].

Entrepreneurial leadership in the healthcare organization fosters innovation and adaptability, enhancing both patient outcomes and operational efficiency. By encouraging initiative among nurses and other healthcare professionals, organizations can implement creative solutions to common challenges. For example, a community hospital's nursing staff developed a telemedicine program that reduced readmission rates by 20%, improving patient follow-up care. Similarly, in another hospital, nurses and pharmacists collaborated to design a medication management application, which enhanced adherence among patients with chronic illnesses. These examples illustrate how entrepreneurial leadership not only motivates healthcare staff but also drives transformative change [16].

However, significant challenges often hinder the implementation of entrepreneurial leadership in healthcare settings. Many institutions adhere to traditional care models, while funding constraints can slow the development of new initiatives. Additionally, a lack of institutional support may discourage nurse-led innovations. For example, hospitals may hesitate to adopt telehealth technology due to financial limitations or resistance from administrators. To overcome these barriers, healthcare organizations must foster a culture of innovation and provide the necessary resources and training to empower healthcare professionals. This shift not only enhances entrepreneurial initiatives but also improves patient outcomes and overall organizational performance [17, 18].

Studies indicate that nurse interns who participate in entrepreneurial leadership programs demonstrate improved performance. Moreover, nursing students should develop entrepreneurial skills to navigate the complexities of the healthcare; as such training enhances both performance and job satisfaction [19]. Integrating entrepreneurship into nursing education increases knowledge and fosters interest in entrepreneurial opportunities within healthcare, which is essential for nurses to adapt and innovate. Participation in entrepreneurial leadership programs has been shown to strengthen nursing interns' entrepreneurial competencies [20]. In conclusion, evidence supports the notion that engagement in entrepreneurial leadership programs significantly

enhances the entrepreneurial behaviors of nursing interns, thereby preparing them for future challenges in healthcare [21]. Therefore, incorporating entrepreneurial leadership can enhance the entrepreneurial and all pertinent elements of nursing interns. Based on this, the study hypothesizes that:

H1 Nurse Interns who participate in the entrepreneurial leadership program demonstrate significantly higher scores in entrepreneurial behavior and all its associated dimensions compared to those in the control group.

Previous studies indicate that entrepreneurial leadership programs foster the development of critical thinking, problem-solving, and creativity among participants [22]. Research suggests that nurses who engage in leadership development programs are more likely to implement innovative solutions to patient care challenges, ultimately improving patient outcomes [23]. Additionally, nursing interns who participate in programs promoting collaboration and interdisciplinary teamwork enhance their innovative thinking, strengthen their competencies in healthcare settings, and contribute to continuous advancements in nursing practice [24].

Entrepreneurial leadership also plays a vital role in ensuring successful project completion and enhancing innovation outcomes. It is reinforced by dynamic skills such as big data analytics and sustainable resilience [25]. This study highlights the significance of entrepreneurial leadership programs in cultivating innovative work environments and improving performance in innovation-related tasks. Therefore, equipping nursing interns with entrepreneurial skills in clinical settings can foster work innovation. Based on this, the study proposed the following hypothesis:

H2 Nurse interns who participate in the entrepreneurial leadership program exhibit considerably higher scores of works innovation and all relevant aspects than those in the control group.

The concept of entrepreneurial leadership (EL) in nursing has gained recognition as a strategy to enhance performance and adaptability among nursing professionals. Recent studies highlight the positive impact of entrepreneurial leadership programs on nurses, particularly in fostering proactive work behavior and career adaptability. Research indicates that nurses who participate in such programs achieve higher performance scores, as EL positively influences proactive behavior and adaptability—both crucial for success in healthcare settings [25].

Leadership development training for nurses significantly strengthens leadership competencies, improves patient outcomes, and enhances organizational effectiveness by preparing nurses for leadership roles and skill implementation [10]. Entrepreneurial leadership also fosters creativity within nursing teams, with factors such as an innovative climate, creative self-efficacy, and team psychological safety mediating this relationship, ultimately improving performance [1]. In conclusion, integrating entrepreneurial leadership principles into nursing internships not only enhances individual student performance but also improves the efficiency of nursing teams in healthcare environments [26]. Based on these insights, the study hypothesized that:

H3 Nurse interns who participate in the entrepreneurial leadership program exhibit significantly higher scores of performances and all relevant aspects than those in the control group.

The aim of the study

Aim

This research aimed to investigate the effect of the entrepreneurial leadership intervention program on nurse interns' work innovation and overall performance in the clinical setting.

Study objectives

1. To assess nursing interns' knowledge of entrepreneurial leadership before and after intervention
2. To evaluate nursing interns' entrepreneurial leadership behavior before and after intervention
3. To measure nursing interns' work innovation before and after intervention
4. To estimate nursing interns' clinical performance before and after intervention
5. To evaluate the effect of entrepreneurial leadership educational program on entrepreneurial behavior, work innovation, and clinical performance among nurse interns.

Methods

Study design

This research employed a two-arm, parallel, open-label randomized controlled trial (RCT) adhering to the Consolidated Standards of Reporting Trials (CONSORT) guidelines [27].

Participants and setting

This study recruited nurse interns who worked 6 h every shift, 36–40 h per week, at all Mansoura University Hospitals in Mansoura Governorate, Egypt. The analysis included students who were currently enrolled in a nursing internship program as part of their final academic requirements, actively participating in hands-on patient care and clinical rotations in hospitals, had at least 6 months of experience, and provided informed consent

to participate in the program. Conversely, nurse interns who were involved in any other intervention program within the last 6 months were excluded. Among the 2410 invited nurse interns, 81 did not match the eligibility requirements, 70 declined to participate, and 103 were piloted. Eventually, 1026 were included and randomly assigned to either the study group ($n = 513$) or the control group ($n = 513$). Generally, 1026 nurse interns (513 in the study group and 513 in the control group) completed the intervention until data collection.

Sample size calculation

To investigate the effect of the entrepreneurial leadership intervention program on nurse interns' innovation and overall performance, the sample was calculated at power 80%, as it is a widely accepted standard in social and behavioral sciences to reduce the likelihood of Type II error. Nurse interns were included in the study if they agreed to participate in the research and matched the eligibility requirements. Accordingly, 513 nursing interns served as the study group, and another 513 served as the control group.

Randomization and blinding

An independent researcher used the "Research Randomizer," a web-based program [28], to randomly assign participants to the study or control groups. After specifying the number of groups and participants, the program generated two sets of 1,026 unique, sorted numbers, which were randomly allocated to either Group 1 (study group) or Group 2 (control group) in a 1:1 ratio. The allocation sequence was concealed using opaque sealed envelopes. Since the intervention was an educational program, blinding the researcher or participants to group assignments was not feasible Cummings [29]. However, to minimize bias, the authors (MS and AA) collected and analyzed the data independently without participating in the intervention program.

Reliability and validity of instruments

Reliability was applied by the researcher for testing the internal consistency of the instruments; these instruments were tested for reliability to estimate the consistency of measurement. Reliability was performed using the Alpha Coefficient test (Cronbach alpha). Internal consistency of the first instrument (Knowledge questionnaire) with Cronbach alpha is ($\alpha = 0.809$), Internal consistency of the second instrument (behavior questionnaire) with Cronbach alpha coefficient is ($\alpha = 0.897$), Internal consistency of the third instrument; work innovation questionnaire is ($\alpha = 0.907$), and Internal consistency of the fourth instrument; clinical performance questionnaire is ($\alpha = 0.863$). Five professionals with backgrounds in academia and clinical settings validated the e-intervention program and data collection tools utilized in this study. The scales were translated into Arabic by using the committee approach [30]. In all tools of data collection, the Factor loadings were acceptable, assessed and confirmed to be above 0.40, supporting the questionnaire's dimensional structure.

Procedures

The entrepreneurial leadership intervention program was developed according to the entrepreneurial leadership theory [31]. The intervention aimed to train nurse interns to maximize their entrepreneurial behaviors that could promote their work innovation and creativity, develop their clinical performance, and enhance their transition to professional practice. By designing workshops that prioritize peer interactions and practical applications, the intervention for the nurse interns' entrepreneurial training program incorporates social learning concepts, especially modeling and observational learning. During these sessions, seasoned nurses and managers model good nursing practices, giving interns a safe space to watch and imitate these actions. As the interns learn via practice and observation, this method not only improves their clinical abilities but also builds their self-efficacy, ultimately closing the gap between theoretical knowledge and real-world application in clinical situations.

The researchers started collecting data from the nurse interns who met the inclusion criteria after receiving legal authorization (Ethical and Research Committee Decision No. Zu.Nur.REC#100; 22/2/2023 and Hospital Administration approval, 3- 2023). Researchers have met participants and held Telegram groups to obtain their cooperation, and verbal consent to be included in the study. Also, for ease of communication, appropriate session times were set and posters and videos related to the program sent. The study was carried out through interviewing, implementation, and evaluation.

Interviewing

Interviewing began in early March 2023 and concluded in April 2023. The study participants were informed about the educational program, its objectives, the intervention, and the one-month and three-month intervention requirements. The educational intervention was conducted twice, with a total of 513 nurse interns in each group. To facilitate the sessions, participants were divided into four groups based on the hospital where they worked, with each group consisting of 128 to 129 nursing interns. The total theoretical duration of the program was 12 h, divided into four sessions of three hours each. The educational intervention was delivered in four sessions per group, with two sessions conducted per week. Each group completed the intervention over two weeks, resulting in a total program duration of two months for all

four groups. Various teaching methods were employed, including lectures, discussions, role-playing, brainstorming, and video materials.

Implementation

Data was collected through direct meetings with nurse interns, during which the study's objectives were explained. Participants were assured that their data would be used exclusively for research purposes. To assess their knowledge of entrepreneurial leadership, a knowledge questionnaire was administered before the educational intervention, immediately after its completion, and three months later. Before designing the sessions, the researchers conducted an extensive review of evidence-based literature. The intervention topics—including entrepreneurial leadership, nurse interns' innovation, and clinical performance—were developed based on literature reviews, assessment analyses, and identified gaps in knowledge (see Table 1 for program details). At the end of the workshop, each participant received a booklet containing the teaching material, which was developed based on a comprehensive literature review [32, 33] and the nursing interns' needs that were identified through interviews.

Evaluation of entrepreneurial leadership educational intervention phase

At the end of the educational intervention and three months later, nurse interns were given a chance to reassess their understanding of entrepreneurial leadership and compare their results with the pre-test. The follow-up questionnaire was completed in the end of July 2023.

First session: This session is structured to foster a collaborative and engaging learning environment. It begins with a warm-up game, such as "Two Truths and a Lie," to help participants get to know each other and build rapport. Following this, a group contract will be established to set expectations and create a safe space for discussion. The program's aims, activities, and timeline have been clarified, ensuring that everyone understands the objectives. The researchers then explained key concepts of entrepreneurial leadership, supported by case studies of successful leaders like Elon Musk and Oprah Winfrey. To highlight the significance of entrepreneurial leadership, participants explored in groups how it affects team relationships and innovation. Lastly, through role-playing exercises, we examined the traits and actions of successful entrepreneurial leaders, giving participants the chance to practice and consider these traits in authentic situations.

In the second session, the entrepreneurial leadership paradigm was explored, with a particular focus on leaders' traits, behaviors, and impact on their organizations. The discussion then shifted to successful entrepreneurs such as Oprah Winfrey and Elon Musk, analyzing their strategies and contributions to their respective industries. Through case studies, participants evaluated these leaders' leadership styles and discussed how they overcame challenges. To foster critical thinking and encourage the practical application of learned concepts, the session concluded with a review of key insights. Additionally,

Table 1 Entrepreneurial leadership training sessions, goals, and activities

Sessions	Goals	Activities
First session (Theoretical background)	1. Establish the group 2. Introduce the program 3. Introduce the concept of entrepreneurial leadership. 4. Principles and benefits of entrepreneurial leadership 5. Explore the importance of entrepreneurial leadership 6. Identify the Qualities and Behaviours of entrepreneurial leaders.	(i) Warm-up game and acquaintances (ii) Establishment of a group contract (iii) Clarification of the program's aim, activities, and timeline (iv) Explanation of the concepts of entrepreneurial leadership by the researcher (v) Explore the importance of entrepreneurial leadership. (vi) Description of the Qualities and Behaviours of Entrepreneurial Leaders.
Second session (model and clarify the successful entrepreneurial leaders)	1. Discuss the model of entrepreneurial leadership 2. Focus on the successful entrepreneurial leaders 3. Examples of successful entrepreneurial leaders	(i) Lecture on the model of entrepreneurial leaders (ii) Lecture on successful entrepreneurial leaders (iii) Provision of examples of successful entrepreneurial leaders. (iv) Review of the day (v) Provision of homework that aims to identify challenges other than those mentioned in the session
Third session Discussion of the Entrepreneurial Leadership Process	1. Complete the discussion on entrepreneurial leadership 2. Challenges and Considerations 3. Identify the process of entrepreneurial leadership.	(i) Sharing homework from the previous session (ii) Brainstorming about entrepreneurial leadership's main components, including experience, transformation, process, and knowledge (iii) Group discussion about the process of entrepreneurial leadership.
Fourth session (personal entrepreneurial leadership plan)	1. Create a personal entrepreneurial leadership plan. 2. Clarify the next intervention.	(i) Participants individually entrepreneurial learning and reflection (ii) Discuss entrepreneurial learning and experience (iii) Discussion about entrepreneurial learning and social interaction (iv) Concluding all sessions

participants were assigned homework to identify contemporary challenges faced by entrepreneurial leaders.

The third session aimed to strengthen learning and promote peer feedback. It began by reviewing the prior session's homework. The primary elements of entrepreneurial leadership—experience, transformation, process, and knowledge—were then the focus of a brainstorming session. Small groups of participants debated these topics, using case studies and real-world examples to support their arguments. To facilitate a collaborative exploration of best practices and creative methods, we finally reconvened for a group discussion, during which each team shared their perspectives on the entrepreneurial leadership process.

The fourth session covered four main aspects, following the format of the entrepreneurial learning sessions: Participants (i) journaled about their entrepreneurial journeys and identified key learning moments; (ii) analyzed the decision-making processes and lessons learned by successful entrepreneurs through case studies; (iii) emphasized social interaction through group discussions and collaborative problem-solving activities, where participants shared their experiences and insights; and (iv) synthesized key takeaways from all discussions in the concluding session, allowing participants to articulate their personal learning outcomes and future action plans. This structured methodology ensures a thorough investigation of entrepreneurial learning from multiple angles.

Control group

Only the material from the first and second sessions was given to nurse interns in the control group. They don't create a personal entrepreneurial leadership plan or take part in entrepreneurial leadership activities. The control group was exempt from both the reflection session and the 3-week entrepreneurial leadership intervention, in contrast to the study group.

Data collection tools

Entrepreneurship knowledge questionnaire

This questionnaire is 5-item multiple-choice questions and 5 items true/false that were used to assess nurse interns' scores of entrepreneurships knowledge. It was developed by the researchers according to previous studies [34, 35] the 10 questions particularly assessed nursing interns' understanding of the entrepreneurship concept (2 questions), the importance of entrepreneurship (2 questions), characteristics of entrepreneurship (2 questions), models (2 questions), and entrepreneurship application strategy (2 questions). The score ranges from 0 to 10, with higher scores indicating greater knowledge.

Table 2 Scores of each dimension of entrepreneurial leadership behaviors on both importance and frequency

Score range	GEL	Explorer	Miner	Accelerator	Integrator
High	34–45	34–45	26–35	42–55	53–70
Medium	23–33	23–33	18–25	31–41	36–52
Low	9–22	9–22	17–24	11–30	14–35

Entrepreneurial leadership behavior questionnaire

Entrepreneurial leader behavior was developed by [36] to assess the importance of various behaviors nurse interns may practice and the extent to which he/she practices these behaviors. It consisted of 50 items categorized into five dimensions, namely: General entrepreneurial leader behavior (GEL, 9 items), explorer behavior (9 items), miner behavior [7] items, accelerator behavior [11] items, and integrator behavior [14] items. The nurse interns' replies ranked on a five-point scale for each behavior, with one being very unimportant and five being extremely important. Then each behavior is scored based on how frequently the supervisor actually performs this behavior on the job: 1 suggests almost never, while 5 indicates almost always. The score of the items was summed up and totally divided by the number of the items, giving a mean score for the entrepreneurial leadership behaviors.

To determine the levels of entrepreneurial leadership behaviors' dimensions, add up the scores under each dimension for each question on both importance and frequency, and then look at Table 2 below that developed by [36] to get an idea into which category your scores fall.

Work innovation questionnaire

This questionnaire was developed by [37]. It aimed to measure work innovation among nurse interns. It involved 51 items, which are categorized into four dimensions, namely: The ability to innovate (eight items), problem-solving abilities (11 items), decision-making abilities (16 items), and risk-taking, encouragement, and moral support of innovation abilities (16 items). Work innovation items were measured on a five-point Likert scale ranging from 1 to 5, for the responses 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree for each area, the score of the items was summed up and divided by the number of the items, giving a mean score for work innovation.

Observation checklist of nurses' performance

This tool was developed by [38] to assess the performance of nursing interns. It consisted of 71 items categories under 9 main dimensions which were: leader (7 items), psychosocial individual (14 items), communication (11 items), general patient care (13 items), vital signs (3 items), medication (7 items), patient status (5 items), planning and evaluation (4 items), and dressing (7 items). Observation checklist scored based on yes, no, or not applicable for each activity. "Yes" scored one point, "no"

scored zero, and "not applicable" were omitted from the calculation. The score of the items was summed up and totally divided by the number of the items, giving a mean score for interns' performance.

Demographic information form

This form asks about nurse interns' age, gender, marital status, and whether attending training courses about leadership.

Data collection and procedure

Data collection began in early March 2023 and ended in July 2023. The nurse interns were split into study and control groups at random. There were four groups, each with a capacity of 128 to129 nursing interns. The program was put into place at the hospital for the chief nurses' internal discussions. Teaching strategies included role-playing, brainstorming, discussions, small-group work, adapted lectures, and video materials. Announcements at their hospitals were used to recruit participants. All possible volunteers received a comprehensive explanation of the study's goals and methods. An informed consent form was requested to be signed by nursing interns who satisfied the requirements for inclusion and consented to participate following the baseline measurements' completion.

Pilot study

A pilot study was conducted to assess the quality and clarity of the intervention materials, the time necessary for data collection, and the clarity, practicability, validity, and reliability of the study measures. The pilot study involved 103 nurse interns (10% of the sample size) who met the inclusion and exclusion criteria but were not part of the study population. The results indicated that no adjustments were required and that the study's measures and intervention materials were understandable.

Ethical considerations

The Ethics Committee of the Faculty of Nursing, Zagazig University, granted ethical approval under (reference number Zu.Nur.REC#100; 22/2/2023). All necessary information about the study was introduced in the first section of the sheet. The questionnaire included a statement related to the aim and nature of the study. All participants who chose the word agree to give their informed consent before beginning their response to the sheet. The respondents were guaranteed the privacy and confidentiality of their answers, the voluntary nature of their involvement, and the fact that their absence would not hurt their grades or result in any negative outcomes. Participants have given their informed consent under the criteria outlined in the Helsinki Declaration. It was determined that participants had the right to withdraw from the study at any time.

Data analysis

Data was altered and coded in order to fit into a form that was specifically made for computer entry. The SPSS (Statistics Package for Social Science) package, version 25, was used to enter and analyze the data. Excel was used to create the graphics. Chi-square analysis and independent t-test were used to assess variations in study and control groups in relation to sample features.

Quantitative data were presented by mean and standard deviation. Independent t-test was used to compare the mean scores among study and control groups for the different study variables throughout the program phases (pre-intervention, immediate post-intervention, and three-month follow-up). In addition, a paired t-test was used to compare the mean scores for the different study variables from pre-intervention to immediate post-intervention, as well as from pre-intervention to follow-up phases.

Linear regression analysis was used to study the effect of entrepreneurial leadership programs on the different study variables. Statistical significance was determined using a two-tailed p-value of <0.05, while a two-tailed p-value of <0.01 indicated high statistical significance.

Results

Table 3 indicates that the mean ages of participants in both groups are nearly identical (23.24 ± 0.493 for the study group and 23.23 ± 0.489 for the control group), with a p-value of 0.799. The proportion of males (40.2% in the study group vs. 39.8% in the control group) and

Table 3 Demographic characteristics on the examined groups of nursing interns ($n = 1026$)

Variables		Study group ($n = 513$)		Control group ($n = 513$)		Test value	*p*-value
		No.	%	No.	%		
Age [a]	Mean ± SD	**23.24 ± 0.493**		**23.23 ± 0.489**		−0.254	0.799
Gender [b]	Male	206	**40.2**	204	**39.8**	0.016	0.899
	Female	307	**59.8**	309	**60.2**		
Marital status [b]	Single	499	**97.3**	489	**95.3**	2.733	0.098
	Married	14	2.7	24	4.7		

SD = standard deviation. *Note*. Every participant in both groups stated that they had never attended any training about entrepreneurial leadership. (a) Analyzed by independent t-test. (b) Analyzed by X^2 test

females (59.8% vs. 60.2% in study and control groups, respectively) is nearly equal. The majority of participants in both groups are single (97.3% in the study group and 95.3% in the control group). The statistical tests indicate no significant differences between both groups across all measured variables, as all p-values are above the common significance level of 0.05. This suggests that the two groups are well-matched, which is crucial for ensuring comparability and minimizing confounding effects in subsequent analyses.

Table 4 specifies that before implementing the program, there was no significant difference in entrepreneurial development knowledge between the study and control groups ($p > 0.05$). However, there were statistically significant differences between them at the post-intervention and follow-up phases, where p-value < 0.01. The study group demonstrated sustained improvements in knowledge from pre-intervention to immediate post (from 0.68 to 10.0, $p < 0.001$) and maintained high scores from immediate post to 3-month follow-up (from 10.0 to 9.96, $p < 0.001$). On the other hand, the control group did not demonstrate statistically significant improvements in knowledge from pre-intervention to immediate post and from immediate post to 3-month follow-up (from 0.65 to 0.66 and from 0.65 to 0.70, $p > 0.05$, respectively).

Table 5 displays that before the implementation of the program, no significant differences were found between the study and control groups in any dimension of entrepreneurial leadership behaviors ($p > 0.05$). However, at both the post-intervention and follow-up phases, statistically significant differences emerged between the two groups across all dimensions of entrepreneurial behavior, with p-values of 0.000 for all independent t-tests. The study group demonstrated highly significant improvements in all entrepreneurial behavior dimensions from pre-intervention to immediate post-intervention and from pre-intervention to follow-up, with p-values of 0.000 for all paired t-tests. Additionally, statistically significant differences were observed in the control group between pre- and immediate post-intervention phases for general entrepreneurial leader behavior and integrator behavior ($p < 0.01$). Likewise, significant differences were noted between pre-intervention and the 3-month follow-up for accelerator and integrator behaviors in the control group ($p < 0.05$).

Table 6 presents a comparison between the study and control nurse interns regarding work innovation dimensions across the various phases of the program. This table shows that there were no significant differences between the study and control groups in work innovation dimensions during the pre-intervention phase (p ˃ 0.05). However, at both the post-intervention and follow-up stages, statistically significant differences emerged between the two groups across all dimensions of work innovation

Table 4 Comparison between study and control nurse interns as regards entrepreneurial leadership development knowledge throughout the program phases ($n = 1026$)

Entrepreneurial leadership development knowledge	Study group ($n = 513$)			Control group ($n = 513$)			Independent t-test1 *p*-value1	Independent t-test2 *p*-value2	Independent t-test3 *p*-value3	Paired t-test1 *p*-value	Paired t-test2 *p*-value	Paired t-test3 *p*-value	Paired t-test4 *p*-value
	Pre	Immediate post	Follow-up	Pre	Immediate post	Follow-up							
Total knowledge score	0.68 ± 1.711	10.0 ± 0.000	9.96 ± 0.214	0.65 ± 0.001	0.66 ± 0.612	0.70 ± 0.494	t = 0.052 *p* = 0.55	t = − 20.354 *p* = 0.000	t = − 19.635 *p* = 0.000	t = -123.34 *p* = 0.000	t = -122.84 *p* = 0.000	t = − 0.493 *p* = 0.07	t = -0.538 *p* = 0.08

Note: **t1 (p1)** = Comparison of mean entrepreneurial leadership development knowledge score pre-intervention among study and control nurse interns (Independent t-test)

t2 (p2) = Comparison of mean entrepreneurial leadership development knowledge score immediate post intervention among study and control nurse interns (independent t-test)

t3 (p3) = Comparison of mean entrepreneurial leadership development knowledge score 3- months follow-up intervention among study and control nurse interns (independent t-test)

Paired t-test 1(P1) = Comparison of entrepreneurial leadership development knowledge among study group pre-intervention and post-intervention

Paired t-test 1(P2) = Comparison of entrepreneurial leadership development knowledge among study group pre-intervention and 3- months follow-up intervention

Paired t-test 1(P3) = Comparison of entrepreneurial leadership development knowledge among control group pre-intervention and post-intervention

Paired t-test 1(P4) = Comparison of entrepreneurial leadership development knowledge among control group pre-intervention and 3-month follow up-intervention

among nurse interns ($p = 0.000$ for all independent t-tests). The study group demonstrated significant and sustained improvements in all work innovation dimensions, from pre-intervention to immediate post-intervention and from pre-intervention to follow-up ($p = 0.000$ for all paired t-tests). These improvements highlight the effectiveness of the intervention program. In the control group, statistically significant differences were observed between pre-intervention and immediate post-intervention phases as regards the ability to innovate and risk-taking dimensions ($p < 0.001$). Also, significant differences were found between pre-intervention and the 3-month follow-up in the ability to innovate ($p < 0.05$).

Table 7 presents a comparison between the study and control nurse interns regarding clinical performance dimensions across the various phases of the program. As shown in the table, no statistically significant differences were observed between the study and control groups in any performance dimensions during the pre-intervention phase ($p > 0.05$). Nevertheless, during the post-intervention and follow-up phases, significant differences were observed between the two groups across all performance dimensions, with p-values of 0.000 for all independent t-tests. The study group achieved significant and sustained improvements in all performance categories from pre-intervention to immediate post-intervention and from pre-intervention to follow-up, with p-values = 0.000 for all paired t-tests, indicating that the intervention had a substantial effect on their development. In the control group, statistically significant differences were observed between the pre-intervention and immediate post-intervention phases in general patient care, planning and evaluation, and dressing domains ($p < 0.05$). Similarly, significant differences were found between the pre-intervention and 3-month follow-up phases in general patient care, vital signs, and planning and evaluation domains ($p < 0.05$).

Table 8 presents the results of a linear regression analysis aimed at studying the influence of the entrepreneurial educational program on various outcomes among the nurse interns in the study group. As obvious from this table, the entrepreneurial educational program has a statistically significant positive influence on entrepreneurial behavior, with a coefficient of 0.291. The program explains 10.5% ($R^2 = 0.105$) of the variance in nurse interns' entrepreneurial behavior. The significant t-value (7.751) and p-value (0.000) confirm that the effect is robust. This suggests that other factors, such as personal motivation, risk-taking tendencies, workplace culture, and external opportunities, may also play crucial roles in shaping entrepreneurial behavior but are not included in this model.

The program has a stronger effect on work innovation behavior ($\beta = 0.941$, $p = 0.000$), with an R^2 value of 0.380, indicating that 38% of the variance in work innovation behavior can be attributed to the intervention. The high t-value (17.706) and F-statistic (313.508) further reinforce the substantial influence of the program in fostering innovation. The program also positively influences nurse interns' performance, with a coefficient of 1.250. The model explains 32.4% ($R^2 = 0.324$) of the variance in performance, which is a notable effect. The t-value (15.656) and p-value (0.000) indicate that the effect is statistically significant. The negative constant value (-118.245) suggests that, in the absence of the program, performance scores might be considerably lower. The high F-value (245.106) supports the strong predictive power of the model. As a result, the program is effective in enhancing various aspects of the nurse interns' professional behaviors. These findings highlight the program's success in developing fundamental professional qualities in nursing, which are required to face the challenges of modern healthcare contexts.

Figure 1 illustrates a comparison between study and control groups regarding various study variables across the different phases of the program. This figure highlights statistically significant differences between the two groups in overall entrepreneurial behavior, work innovation, and performance, particularly at the immediate post-intervention and follow-up stages, with p-values of 0.000.

Discussion

Comparison between study and control groups as regards nurse interns' entrepreneurial leadership development knowledge before and after intervention

The study findings revealed that before implementing the program, there was no significant difference in entrepreneurial development knowledge between the study and control groups. However, there were statistically significant differences between them at the post-intervention and follow-up phases. The study group demonstrated sustained improvements in knowledge from pre-intervention to immediate post and maintained high scores from immediate post to 3-month follow-up. On the other hand, the control group did not demonstrate statistically significant improvements in knowledge from pre-intervention to immediate post and from immediate post to 3-month follow-up. The statistically significant improvements in the study group highlight the impact of structured entrepreneurial leadership training on nurse interns' knowledge development. The results emphasize the importance of integrating such educational interventions into nursing curricula to equip future nurses with essential entrepreneurial skills for innovation and leadership in healthcare settings. On the other hand, the control group did not show significant improvements, which suggests that without targeted educational interventions,

Table 5 Comparison between study and control nurse interns as regards entrepreneurial leadership behavior dimensions throughout the program phases ($n=1026$)

Entrepreneurial behavior dimensions	Study group ($n=513$)			Control group ($n=513$)			Independent t-test1 *p*-value1	Independent t-test2 *p*-value2	Independent t-test3 *p*-value3	Paired t-test1 *p*-value	Paired t-test2 *p*-value	Paired t-test3 *p*-value	Paired t-test4 *p*-value
	Pre	Immediate post	Follow-up	Pre	Immediate post	Follow-up							
General entrepreneurial leader behavior	29.41 ± 3.83	44.09 ± 2.21	45.0 ± 0.00	29.48 ± 3.89	29.23 ± 3.71	29.45 ± 3.72	**t = 0.324** $p=0.75$	**t = − 77.84** $p=0.000$	**t = − 94.78** $p=0.000$	**t = -74.31** $p=0.000$	**t = -92.19** $p=0.000$	**t = 3.44** $p=0.001$	t = 0.366 $p=0.72$
Explorer behavior	29.71 ± 3.19	44.22 ± 3.38	45.0 ± 0.00	29.71 ± 3.19	29.69 ± 3.13	29.65 ± 3.34	**t = 0.000** $p=1.000$	**t = − 83.83** $p=0.000$	**t = − 104.09** $p=0.000$	**t = -80.46** $p=0.000$	**t = -108.34** $p=0.000$	t = 0.622 $p=0.53$	t = 0.968 $p=0.33$
Miner behavior	23.21 ± 3.02	35.00 ± 0.00	35.00 ± 0.00	23.21 ± 3.02	23.21 ± 3.02	23.18 ± 2.93	**t = 0.000** $p=1.000$	**t = − 88.31** $p=0.000$	**t = − 91.31** $p=0.000$	**t = − 80.31** $p=0.000$	**t = − 80.31** $p=0.000$	t = 0.332 $p=0.52$	t = 0.352 $p=0.59$
Accelerator behavior	37.29 ± 3.61	55.0 ± 0.00	55.0 ± 0.00	37.30 ± 3.64	37.29 ± 3.61	37.17 ± 3.62	**t = 0.026** $p=0.98$	**t = − 111.14** $p=0.000$	**t = − 111.504** $p=0.000$	**t = − 111.14** $p=0.000$	**t = − 111.14** $p=0.000$	t = 0.179 $p=0.86$	**t = 2.12** $p=0.03$
Integrator behavior	48.40 ± 4.18	70.0 ± 0.00	70.0 ± 0.00	48.42 ± 4.28	48.27 ± 4.20	48.77 ± 4.02	**t = 0.81** $p=0.94$	**t = − 117.91** $p=0.000$	**t = − 119.71** $p=0.000$	**t = − 117.09** $p=0.000$	**t = − 117.09** $p=0.000$	**t = 2.801** $p=0.005$	**t = − 4.84** $p=0.000$

Note: **t1 (p1)** = Comparison of mean for each entrepreneurial behavior's dimension pre intervention among study and control nurse interns (Independent t-test)

t2 (p2) = comparison of mean for each entrepreneurial behavior's dimension immediate post intervention among study and control nurse interns (independent t-test)

t3 (p3) = comparison of mean for each entrepreneurial behavior's dimension 3- months follow-up intervention among study and control nurse interns (independent t-test)

Paired t-test 1(P1) = Comparison of each entrepreneurial behavior's dimension among study group pre-intervention and post-intervention

Paired t-test 1(P2) = Comparison of each entrepreneurial behavior's dimension among study group pre-intervention and 3- months follow up-intervention

Paired t-test 1(P3) = Comparison of each entrepreneurial behavior's dimension among control group pre-intervention and post-intervention

Paired t-test 1(P4) = Comparison of each entrepreneurial behavior's dimension among control group pre-intervention and 3- months follow up-intervention

entrepreneurial leadership knowledge does not naturally improve over time.

The previous findings are consistent with that of [39], who revealed that students who participated in the entrepreneurial leadership program showed significant increases in entrepreneurial knowledge and attitudes post-intervention. However, the control group, which did not receive the intervention, did not display comparable gains, supporting the efficacy of targeted educational programs. On the contrary [40], indicated that only small effect sizes for entrepreneurial education in increasing entrepreneurial intention and self-efficacy. Notably, the duration of the programs was a predictor of larger effect sizes, suggesting that shorter interventions might not yield significant improvements. This implies that not all entrepreneurship education programs lead to substantial knowledge gains, especially if they are of limited duration. This contradiction could be due to some factors such as program duration and specific content can influence the extent of these improvements, and not all studies find uniformly positive results across all measured outcomes.

Comparison between study and control groups as regards nurse interns' entrepreneurial leadership behaviors before and after intervention

The findings of this study reveal that before the program, no significant differences in entrepreneurial leadership behaviors were found between the study and control groups. However, post-intervention and follow-up results showed statistically significant improvements across all dimensions for the study group. While the control group showed some gains in general entrepreneurial leader, integrator, and accelerator behaviors, these were limited compared to the study group, which demonstrated highly significant improvements in all areas. The observed results can be attributed to the structured and targeted nature of the entrepreneurial leadership program, which provided nurse interns with essential knowledge, skills, and experiential learning opportunities that directly enhanced their entrepreneurial behaviors. Before the intervention, both groups had similar baseline levels, indicating that neither had a prior advantage in entrepreneurial leadership behaviors. However, after the program, the study group exhibited statistically significant improvements across all dimensions, suggesting that the program effectively fostered entrepreneurial competencies through its structured curriculum, mentorship, and active learning strategies.

In contrast, the control group, which did not receive the intervention, showed only limited improvements in certain dimensions, likely due to indirect exposure to entrepreneurial concepts through their clinical experiences or institutional environment. However, these gains were not as substantial or consistent as those in the study group, reinforcing the effectiveness of a structured educational intervention in promoting entrepreneurial leadership behaviors.

The previous findings are in the same line with that of [41, 42], who assessed the impact of a developmental leadership model on leadership behaviors and indicated that there was a limited increase in favorable leadership behaviors and a significant reduction in unfavorable behaviors. Similarly [43], revealed that entrepreneurship education can affect nurses' entrepreneurship behaviors. Likewise [44], indicated that the experimental group showed significant improvements in coaching-based leadership skills post-intervention and at follow-up assessments. In contrast, the control group did not exhibit significant changes during the same period. In contrast [45], who assessed the impact of entrepreneurship education on students' entrepreneurial intentions, found significant increases in attitudes toward behavior post-intervention; the effects on subjective norms and perceived behavioral control were positive but not statistically significant. This suggests that while certain aspects of entrepreneurial intention may improve, others might remain unaffected by the education program.

Comparison between study and control groups as regards nurse interns' work innovation before and after intervention

The study findings discovered that no significant differences in work innovation dimensions were found between the study and control groups before the intervention. However, post-intervention and follow-up results revealed statistically significant improvements across all dimensions for the study group, indicating the program's effectiveness. While the control group showed some gains in the ability to innovate and risk-taking dimensions, these improvements were limited compared to the study group, which demonstrated sustained enhancements in all areas of work innovation.

The results suggest that before the intervention, both groups had comparable levels of work innovation, indicating that external factors did not initially influence their innovation capabilities. However, after the program, the study group exhibited significant and sustained improvements across all dimensions of work innovation, which can be attributed to the structured training, mentorship, and experiential learning provided by the program. In contrast, the control group exhibited only limited gains in certain dimensions, such as the ability to innovate and risk-taking. This suggests that while natural professional growth may contribute to some development in work innovation, structured training is crucial for comprehensive and lasting improvements.

Table 6 Comparison between study and control nurse interns as regards dimensions of work innovation throughout the program phases ($n=1026$)

Entrepreneurial behavior dimensions	Study group ($n=513$)			Control group ($n=513$)			Inde-pendent t-test1 *p*-value1	Inde-pendent t-test2 *p*-value2	Inde-pendent t-test3 *p*-value3	Paired t-test1 *p*-value	Paired t-test2 *p*-value	Paired t-test3 *p*-value	Paired t-test4 *p*-value
	Pre	Immediate post	Follow-up	Pre	Immediate post	Follow-up							
The ability to innovate	22.75 ± 5.48	40.0 ± 0.000	40.0 ± 0.000	22.99 ± 5.65	23.46 ± 5.10	23.73 ± 5.18	**t = 0.679**	**t = −73.43**	**t = −71.09**	**t = -71.29**	**t = -71.29**	**t = −5.66**	**t = −8.29**
							p = 0.49	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.000
Problem solving	36.58 ± 3.69	55.0 ± 0.000	55.0 ± 0.000	36.62 ± 4.92	36.61 ± 3.68	36.78 ± 3.71	**t = 0.822**	**t = −113.3**	**t = −111.32**	**t = -113.17**	**t = -113.17**	t = 0.081	t = 0.092
							p = 0.45	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.56	*p* = 0.66
Decision making	54.31 ± 5.01	80.0 ± 0.000	79.74 ± 0.85	54.35 ± 4.66	54.31 ± 5.01	54.42 ± 5.32	**t = −0.448**	**t = −116.25**	**t = −106.18**	**t = −116.25**	**t = −114.53**	t = −0.435	t = −0.301
							p = 0.72	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.71	*p* = 0.65
Risk-taking, encouragement and moral support of innovation	54.31 ± 6.52	80.0 ± 0.000	78.26 ± 4.41	54.45 ± 6.53	54.30 ± 6.54	54.48 ± 6.55	**t = 0.345**	**t = −89.05**	**t = −68.19**	**t = −89.24**	**t = −68.35**	**t = 3.44**	t = −0.827
							p = 0.73	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.000	*p* = 0.001	*p* = 0.41

Note: **t1 (p1)** = Comparison between study and control nurse interns as regards pre intervention's mean score for each work innovation's dimension (Independent t-test)

t2 (p2) = Comparison between study and control nurse interns as regards immediate post intervention's mean score for each work innovation's dimension (independent t-test)

t3 (p3) = Comparison between study and control nurse interns as regards 3- months follow-up's mean score for each work innovation's dimension (independent t-test)

Paired t-test 1(P1) = Comparison between pre-intervention and post-intervention as regards the study group for each work innovation's dimension

Paired t-test 1(P2) = Comparison between pre-intervention and 3- months follow up-intervention as regards the study group for each work innovation's dimension

Paired t-test 1(P3) = Comparison between pre-intervention and post-intervention as regards the control group for each work innovation's dimension

Paired t-test 1(P4) = Comparison between pre-intervention and 3- months follow up-intervention as regards the control group for each work innovation's dimension

The previous findings are congruent with that of [46, 47], and [48, 49], who assessed the impact of a developmental leadership model on leadership behaviors and indicated that there was a limited increase in favorable leadership behaviors and a significant reduction in unfavorable behaviors.

Comparison between study and control groups as regards nurse interns' clinical performance before and after intervention

The findings from our study highlighted that before the intervention, no significant differences were found between the study and control groups in any performance dimensions. However, post-intervention and follow-up results revealed significant improvements across all performance dimensions in the study group. These improvements were sustained over time. In contrast, the control group showed limited gains in specific areas, such as general patient care, planning and evaluation, dressing, and vital signs. The observed results can be attributed to the structured entrepreneurial leadership program, which provided nurse interns with targeted training in critical thinking, decision-making, and proactive problem-solving. The program likely enhanced their ability to integrate innovative approaches into patient care, thereby improving their overall clinical performance. However, the significant and sustained improvements in the study group suggest that exposure to entrepreneurial leadership principles fostered greater confidence, adaptability, and initiative in handling clinical responsibilities. By contrast, the control group exhibited only limited improvements, likely due to natural experiential learning rather than systematic intervention.

The previous findings are harmonious with that of [50–52], and [53], which investigated the effects of an intervention program on nurses' knowledge and practices, and they reported that pre-intervention assessments indicated no significant differences between the study and control groups. Following the intervention, the study group demonstrated significant enhancements in both knowledge and practice mean scores, while the control group exhibited only slight improvements. This suggests the intervention's role in elevating nursing performance.

The influence of the entrepreneurial educational program on various outcomes among the nurse interns

The linear regression analysis demonstrates significant positive impacts of the entrepreneurial educational program on the overall entrepreneurial behavior, work innovation, and clinical performance among nurse interns in the study group. These findings underline the program's effectiveness in fostering essential professional competencies in nursing, which are critical for addressing the challenges of modern healthcare environments.

Table 7 Comparison between study and control nurse interns as regards dimensions of clinical performance throughout the program phases ($n=1026$)

Entrepreneurial behavior dimensions	Study group ($n=513$)			Control group ($n=513$)			Independent t-test1 *p*-value1	Independent t-test2 *p*-value2	Independent t-test3 *p*-value3	Paired t-test1 *p*-value	Paired t-test2 *p*-value	Paired t-test3 *p*-value	Paired t-test4 *p*-value
	Pre	Immediate post	Follow-up	Pre	Immediate post	Follow-up							
Leader	13.20 ± 1.74	21.0 ± 0.000	20.20 ± 1.83	13.39 ± 1.79	13.60 ± 1.83	13.09 ± 2.061	**t = 1.75** $p=0.08$	**t = − 4.91** $p=0.000$	**t = − 8.928** $p=0.000$	**t = -101.37** $p=0.000$	**t = -62.83** $p=0.000$	t = − 0.593 $p=0.45$	t = -0 0.546 $p=0.54$
Psychological individual	24.54 ± 3.39	39.0 ± 0.000	37.28 ± 3.75	24.31 ± 3.75	24.64 ± 1.14	24.89 ± 0.45	**t = 0.430** $p=0.73$	**t = − 7.15** $p=0.000$	**t = 9.699** $p=0.000$	**t = -96.37** $p=0.000$	**t = − 56.81** $p=0.000$	t = − 0.748 $p=0.06$	t = -0. 809 $p=0.08$
Communication	21.17 ± 2.65	33.0 ± 0.000	31.65 ± 2.49	21.23 ± 2.55	21.59 ± 2.61	21.67 ± 0.51	**t = 0.41** $p=0.68$	**t = − 20.86** $p=0.000$	**t = 88.191** $p=0.000$	**t = − 101.18** $p=0.000$	**t = − 67.09** $p=0.000$	t = − 0.562 $p=0.08$	t = -0. 974 $p=0.55$
General patient care	24.88 ± 2.95	25.11 ± 3.29	39.0 ± 0.000	24.90 ± 2.94	24.88 ± 2.95	24.89 ± 2.07	**t = 0.106** $p=0.92$	**t = 1.198** $p=0.000$	**t = − 103.48** $p=0.000$	**t = − 105.30** $p=0.000$	**t = − 108.33** $p=0.000$	**t = − 3.75** $p=0.000$	**t = − 2.14** $p=0.03$
Vital signs	5.51 ± 0.99	9.0 ± 0.000	9.0 ± 0.000	5.52 ± 0.98	5.56 ± 1.04	5.47 ± 0.97	**t = 0.189** $p=0.85$	**t = − 74.95** $p=0.000$	**t = − 82.09** $p=0.000$	**t = − 79.21** $p=0.000$	**t = − 79.21** $p=0.000$	t = − 1.79 $p=0.07$	**t = 2.41** $p=0.01$
Medication	13.30 ± 1.81	21.0 ± 0.000	21.0 ± 0.000	13.35 ± 1.79	13.39 ± 1.88	13.30 ± 1.79	**t = 0.433** $p=0.67$	**t = − 91.49** $p=0.000$	**t = − 97.14** $p=0.000$	**t = − 96.43** $p=0.000$	**t = − 96.43** $p=0.000$	t = − 1.35 $p=0.17$	t = 1.75 $p=0.08$
Patient status	9.51 ± 1.39	15.0 ± 0.000	15.0 ± 0.000	9.57 ± 1.41	9.60 ± 1.45	9.54 ± 1.39	**t = 0.581** $p=0.56$	**t = − 84.44** $p=0.000$	**t = − 88.37** $p=0.000$	**t = − 89.52** $p=0.000$	**t = − 89.52** $p=0.000$	t = − 1.37 $p=0.30$	t = 0.764 $p=0.44$
Planning and evaluation	7.55 ± 1.30	12.0 ± 0.000	12.0 ± 0.000	7.57 ± 1.29	7.62 ± 1.34	7.72 ± 1.41	**t = 0.193** $p=0.85$	**t = − 74.008** $p=0.000$	**t = − 68.89** $p=0.000$	**t = − 77.73** $p=0.000$	**t = − 77.73** $p=0.000$	**t = − 2.14** $p=0.03$	**t = − 4.63** $p=0.000$
Dressing	13.0 ± 1.43	21.0 ± 0.000	21.0 ± 0.000	13.0 ± 1.43	13.12 ± 1.58	13.0 ± 1.43	**t = 0.000** $p=1.000$	**t = − 112.79** $p=0.000$	**t = − 126.47** $p=0.000$	**t = − 127.17** $p=0.000$	**t = − 127.17** $p=0.000$	**t = − 3.13** $p=0.002$	t = − 0.333 $p=0.74$

Note: **t1 (p1)** = Comparison between study and control nurse interns as regards pre intervention's mean score for each performance's dimension (Independent t-test)

t2 (p2) = Comparison between study and control nurse interns as regards immediate post intervention's mean score for each performance's dimension (independent t-test)

t3 (p3) = Comparison between study and control nurse interns as regards 3- months follow-up's mean score for each performance's dimension (independent t-test)

Paired t-test 1(P1) = Comparison between study group pre-intervention and post-intervention as regards each performance's dimension

Paired t-test 1(P2) = Comparison between study group pre-intervention and 3-month follow-up intervention as regards each performance's dimension

Paired t-test 1(P3) = Comparison between control group pre-intervention and post-intervention as regards each performance's dimension

Paired t-test 1(P4) = Comparison between control group pre-intervention and 3-month follow-up intervention as regards each performance's dimension

Table 8 The results of linear regression analysis to study the influence of the entrepreneurial educational program on different study variables among nurse interns' study group ($n=513$)

Variables	Unstandardized coefficient		t	Sig.	*R*	R^2	F
	β	Std. Error					
The influence of the entrepreneurial leadership educational program on entrepreneurial behavior:							
Constant	377.24	15.621	24.149				
Entrepreneurial educational program	**0.291**	0.038	**7.751**	**0.000****	0.324	**0.105**	60.072
The influence of the entrepreneurial leadership educational program on work innovation behavior:							
Constant	116.604	22.106	5.275				
Entrepreneurial educational program	**0.941**	0.053	**17.706**	**0.000****	0.617	**0.380**	**313.508**
The influence of the entrepreneurial leadership educational program on nurse interns' performance:							
Constant	**−118.245**	33.232	−3.558				
Entrepreneurial educational program	**1.250**	0.080	**15.656**	**0.000****	0.569	**0.324**	**245.106**

β = regression coefficients. *Statistically significant at $P<0.05$. ** Highly statistically significant at $P<0.001$

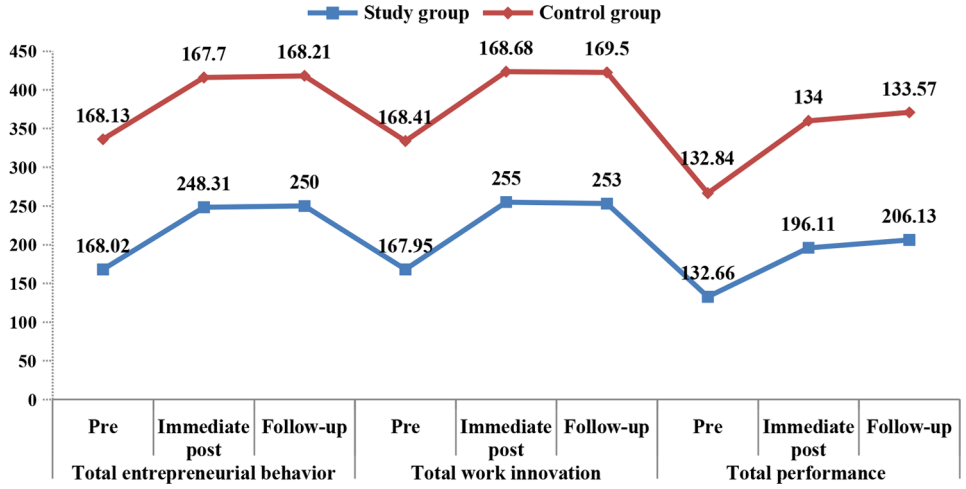

Fig. 1 Comparison between study and control nurse interns as regards different study variables throughout the program phases ($n=1026$)

The significant influence of the program on entrepreneurial behavior suggests that targeted educational interventions can enhance nurse interns' ability to exhibit proactive and innovative leadership traits. This aligns with the findings of [54], who reported that entrepreneurial leadership training programs in healthcare cultivate behaviors such as initiative-taking, problem-solving, and adaptability, which are vital for effective nursing practice. The program's focus on building these competencies likely contributed to the observed improvements. The relatively modest R^2 value for entrepreneurial behavior suggests that other factors, such as personal motivation, risk-taking tendencies, workplace culture, and external opportunities, may also play crucial roles in shaping entrepreneurial behavior but are not included in this model.

Interestingly, the program has a stronger effect on work innovation behavior, underscoring its function in promoting innovative ideas and their use in healthcare settings. This conclusion is supported by prior research carried out by [55], which shows that nurses who get education that emphasizes innovation are better equipped to develop and implement solutions that promote patient outcomes and operational efficiency. Similarly, the positive influence on performance further demonstrates the program's broad applicability in enhancing nurse interns' clinical and administrative skills. These results are consistent with the findings of [56], which identified a strong relationship between professional development programs and improvements in nurses' overall performance, including communication, decision-making, and leadership skills.

Despite the positive results, some critics question the generalizability of these findings. For instance [57], argued that the effectiveness of educational programs may vary depending on organizational culture, resource availability, and baseline competencies of participants. Moreover, resource-intensive programs may not be feasible in all healthcare systems, particularly those with limited budgets and infrastructure. As noted by [58], scalability remains a significant challenge, particularly in low-resource settings where access to comprehensive training is constrained.

Limitations and future directions

Despite the respected insights gained from this study, some limitations should be acknowledged. First, the study relies on self-reported data and social desirability bias in self-reported questionnaires, as respondents may provide answers they perceive as socially acceptable rather than fully reflective of their actual behaviors or attitudes. To mitigate this, we assured participants of their anonymity and confidentiality, reducing the likelihood of response distortion. Additionally, we utilized validated measurement scales with proven reliability in prior research, which helped improve the accuracy of self-reported data. Future studies could enhance the forcefulness of findings by employing multi-source data collection methods, such as supervisor or peer assessments or implicit measures, to minimize bias.

Second, the study did not account for potential moderating factors, such as personality traits, prior entrepreneurial exposure, or institutional support, which may influence how interns respond to the program. Future research could explore these variables to refine intervention strategies and tailor entrepreneurial leadership programs to individual needs.

Conclusion

This study demonstrates the significant impact of a structured entrepreneurial educational program on enhancing entrepreneurial behavior, work innovation, and performance among nurse interns. The intervention led to substantial and sustained improvements in various professional competencies, with the study group consistently outperforming the control group. These results emphasize the importance of targeted leadership development programs in fostering critical skills and promoting long-term knowledge retention and practical application. The findings highlight the potential of educational interventions to improve performance and innovation in nursing practice, making them a valuable tool for workforce development.

Implications for nursing management and nurse educators

The study underscores the importance of designing and implementing structured, targeted educational interventions to develop entrepreneurial leadership among nurse interns. Nursing managers and educators can cultivate a new generation of nurses equipped with entrepreneurial leadership skills, ultimately improving patient care, healthcare innovation, and organizational efficiency by implementing the following actionable insights: **For nursing management**: (1) Hospital administrators should incorporate structured entrepreneurial leadership programs into nurse internship and continuing education curricula to enhance nurses' innovation, decision-making, and adaptability. (2) Nurse managers should create an environment that supports creativity by allowing interns and staff to propose new ideas, implement process improvements, and engage in problem-solving discussions. (3) Assign experienced nurses or entrepreneurial leaders as mentors to guide interns in developing leadership skills, resilience, and innovative thinking in clinical settings. (4) Encourage collaboration between nurses, physicians, pharmacists, and other healthcare professionals to foster teamwork and interdisciplinary innovation in patient care. (5) Nursing leadership should provide funding, time, and tools to support nurse-led innovation projects, ensuring that promising ideas are developed and implemented in practice. (6) Recognize and reward nurses who demonstrate entrepreneurial leadership, creativity, and problem-solving skills, reinforcing a culture of continuous improvement. (7) Regularly assess the impact of entrepreneurial leadership initiatives and expand successful strategies across departments to maximize organizational benefits.

For nurse educators (1) Nursing education programs should integrate entrepreneurial leadership concepts into coursework, ensuring that students develop leadership and innovation competencies alongside clinical skills. (2) Use experiential learning approaches by utilizing case studies, role-playing, business simulations, and problem-based learning to provide nursing students with real-world scenarios that enhance critical thinking and innovation. (3) Develop entrepreneurship-focused workshops by offering specialized training sessions on leadership, innovation management, and healthcare entrepreneurship to prepare nurses for dynamic and evolving healthcare environments. (4) Encourage research and evidence-based practice by supporting students in conducting research on innovative nursing practices and entrepreneurial approaches to solving healthcare challenges. (5) Foster resilience and adaptive thinking by training nursing students to handle uncertainty, adapt to changing healthcare landscapes, and develop proactive mindsets to manage challenges effectively. (6) Educators should incorporate digital health, artificial intelligence, and business analytics into nursing education to equip students with modern entrepreneurial skills. (7) Build industry partnerships by collaborating with healthcare organizations, startups, and business incubators to expose students to real-world entrepreneurial experiences and innovation-driven projects.

Acknowledgements

We express our heartfelt gratitude to everyone who participated in the study. The authors thank the Deanship of Scientific Research at Shaqra University for supporting this work.

Author contributions

Made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; MS, HE, and ZA. Involved in drafting the manuscript or revising it critically for important intellectual

content; MS, HE, ZA and AA. The final approval of the version to be published has been given. Each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content; MS, HE, ZA, AA, HD and AE. Agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. MS, HE, ZA, AA, HD and AE.

Funding
The present study did not receive any dedicated financial funding from public, commercial, or not-for-profit funding organizations.

Data availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
The Ethics Committee of the Faculty of Nursing, Zagazig University, granted ethical approval under (reference number Zu.Nur.REC#100; 22/2/2023). All necessary information about the study was introduced in the first section of the sheet. The questionnaire included a statement related to the aim and nature of the study. All participants who chose the word agree to give their informed consent before beginning their response to the sheet. The respondents were guaranteed the privacy and confidentiality of their answers, the voluntary nature of their involvement, and the fact that their absence would not hurt their grades or result in any negative outcomes. Participants have given their informed consent under the criteria outlined in the Helsinki Declaration. It was determined that participants had the right to withdraw from the study at any time.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Nursing Sciences, College of Applied Medical Science, Shaqra University, Shaqra, Saudi Arabia
[2]Nursing Administration, Faculty of Nursing, Zagazig University, Zagazig, Egypt
[3]Nursing Department,North Private College of Nursing, Arar, Northern Borders, Saudi Arabia
[4]Department of Nursing, College of Nursing and Health Sciences, Jazan University, Jazan, Saudi Arabia
[5]Nursing Administration, Faculty of Nursing, Mansoura University, Mansoura, Egypt

Received: 4 March 2025 / Accepted: 17 April 2025
Published online: 08 May 2025

References

1. Zou Y, Wang L, Zheng D, Li H, Sun R, Zhang Z. Exploration of undergraduate nursing students' perspectives on conducting specialized nursing education during internship: A phenomenological research study. Nurse Educ Pract. 2024;80:104103.
2. Elewa AH, El Banan SH. Work design, entrepreneurial leadership, and innovative work behavior as perceived by staff nurses. Egypt Nurs J. 2022;19(3):313–21.
3. Pauceanu AM, Rabie N, Moustafa A, Jiroveanu DC. Entrepreneurial leadership and sustainable development—a systematic literature review. Sustainability. 2021;13(21):11695.
4. Rezvani SM, Falcão MJ, Komljenovic D, de Almeida NM. A systematic literature review on urban resilience enabled with asset and disaster risk management approaches and GIS-based decision support tools. Appl Sci. 2023;13(4):2223.
5. Beaudet O, Pesut D, Lemberger O. The ANA innovation engine: activating innovation through education and communities of practice. Online J Issues Nurs. 2023;28(2).
6. Alsadaan N, Salameh B, Reshia FAAE, Alruwaili RF, Alruwaili M, Ali A, Jones SA, L. K. Impact of nurse leaders behaviors on nursing staff performance: a systematic review of literature. Volume 60. INQUIRY: The Journal of Health Care Organization, Provision, and Financing; 2023. p. 00469580231178528.
7. Ndlovu S, van Wyk NC, Leech R. Professional nurses' perspectives of an ideal performance management process. Health SA Gesondheid. 2024;29(1).
8. Neri J. Addressing high nursing turnover: analysis of theoretical concepts and case study. Health Econ Manage Rev. 2024;5(2):32–46.
9. Araby Ebraheem SM, Rashed SE. Effect of educational program about ambidextrous leadership for nursing managers on entrepreneurial orientation and organizational ingenuity. Assiut Sci Nurs J. 2024;12(45):129–47.
10. Ravet-Brown TÉ, Furtner M, Kallmuenzer A. Transformational and entrepreneurial leadership: A review of distinction and overlap. RMS. 2024;18(2):493–538.
11. Khan H, Rehmat M, Butt TH, Farooqi S, Asim J. Impact of transformational leadership on work performance, burnout and social loafing: a mediation model. Future Bus J. 2020;6(1):40.
12. Givens RJ. Transformational leadership: the impact on organizational and personal outcomes. Emerg Leadersh Journeys. 2008;1(1):4–24.
13. Moustafa Saleh MS, Elsabahy HE, Abdel-Sattar SAL, Abd-Elhamid ZN, Thobaity A, Mohammed Aly A, S. M., Shokry WM. Fostering green transformational leadership: the influence of green educational intervention on nurse managers' green behavior and creativity. BMC Nurs. 2024;23(1):393. https://doi.org/10.1186/s12875-023-02382-x.
14. Karimi S, Ahmadi Malek F, Farani Y, A., Liobikienė G. The role of transformational leadership in developing innovative work behaviors: the mediating role of employees' psychological capital. Sustainability. 2023;15(2):1267.
15. Awad NHA, Zabady HAH, Elbialy GG, Ashour HMAAA. Entrepreneurial leadership, nurses' proactive work behavior, and career adaptability: a structural equation model. BMC Nurs. 2024;23(1):140.
16. Kirkpatrick H, McCoy L, Bowers A. Leveraging entrepreneurial leadership in healthcare: A pathway to innovation. J Nurs Adm Manag. 2023;31(2):315–22.
17. Kirkpatrick LA, Schlaff R. Innovative leadership in healthcare: strategies for success. J Healthc Manag. 2023;68(2):123–35.
18. Saleh M, Elsayed-El A, Elsabahy HE, Ata AA. Visionary leadership: the mediating role of organizational support on nurse interns' creativity and organizational effectiveness. BMC Nurs. 2024. https://doi.org/10.1186/s12912-025-02951-y.
19. Omer T. Leadership development training program's impact on acquisition of leadership competencies for nurses a pilot study. J Pioneer Med Sci. 2024;13(4).
20. Kim YJ, Lim JY. Predictive models for nurses' entrepreneurial intentions using comparison of competing models. Int J Environ Res Public Health. 2022;19(10):6027.
21. Colichi RMB, Spiri WC, Juliani CMCM, Lima SAM. Teaching entrepreneurship in undergraduate nursing course: evaluation of an educational proposal. Revista Brasileira De Enfermagem. 2023;76(2):e20210244.
22. Suwarni T. Principal leadership in improving students' creativity and entrepreneurial innovation. IJOBBA: Int J Bunga Bangsa Cirebon. 2024;3(1):219–28.
23. Ibrahim A, Al-refaei AAA, Alshuhumi S, Al-Hidabi D, Ateeq A. The effect of entrepreneurial leadership on employee's creativity and sustainable innovation performance in education sector: a literature review. Bus Dev Via AI Digitalization: Volume. 2024;2:143–54.
24. Ilhami SD. Entrepreneurial leadership, innovative behavior, organizational effectiveness: A mediation analysis. JOELS: J Election Leadersh. 2024;5(1):38–54.
25. Tariq R, Wang Y, Latif KF. Entrepreneurial leadership for project success through big data capabilities, sustainable resilience and knowledge sabotage behaviour. International Journal of Organization Theory & Behavior. 2025.
26. Asad M, Bait Ali Sulaiman MA, Ba Awain AMS, Alsoud M, Allam Z, Asif MU. Green entrepreneurial leadership, and performance of entrepreneurial firms: does green product innovation mediates? Cogent Bus Manage. 2024;11(1):2355685.
27. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomized trials. J Pharmacol Pharmacotherapeutics. 2010;1(2):100–7.
28. Thompson SK. Sampling. Volume 755. Wiley; 2012.
29. Urbaniak GC, Plous S. Research randomizer (Version 4.0) [Computer software]. Retrieved on July 10, 2016 and December 1, 2016. 2013

30. Cummings SR, Grady D, Hulley SB. Designing a randomized blinded trial. Designing Clin Res. 2007;3(1):147–61.
31. Fiet JO. The pedagogical side of entrepreneurship theory. J Bus Ventur. 2001;16(2):101–17.
32. Bagheri A, Pihie ZAL. Entrepreneurial leadership: towards a model for learning and development. Hum Resource Dev Int. 2011;14(4):447–63.
33. Moustafa Saleh MS, Elsabahy HES. Integrating sustainability development education program in nursing to challenge practice among nursing interns in health care. J Nurs Adm Manag. 2022;30(8):4419–29.
34. Furukawa R, Driessnack M, Colclough Y. A committee approach maintaining cultural originality in translation. Appl Nurs Res. 2014;27(2):144–6.
35. Abdullah Alshammari S, Rehman AU, Alreshoodi A, S., Rab A, M. How entrepreneurial competencies influence the leadership style: A study of Saudi female entrepreneurs. Cogent Bus Manage. 2023;10(2):2202025.
36. Pinela N, Guevara R, Armijos M. Entrepreneurial leadership, work engagement, and innovative work behavior: the moderating role of gender. Int J Econ Bus Adm. 2022;10(2):19–40.
37. Saleh M. Analyzing the relationship between administrative empowerment and innovative administrative behavior. a field study for managers of the administrative system at Taif University. 2013.
38. Ahmed MF, Sleem WF, Kassem AH. Effect of working condition and fatigue on performance of staff nurses at Mansoura university hospital. J Nurs Health Sci. 2015;4(3):83–91.
39. Núñez-Canal M, Ponce S, Azqueta R, A., Montoro-Fernández E. How effective is entrepreneurship education in schools? An empirical study of the new curriculum in Spain. Educ Sci. 2023;13(7):740.
40. Martínez-Gregorio S, Badenes-Ribera L, Oliver A. Effect of entrepreneurship education on entrepreneurship intention and related outcomes in educational contexts: A meta-analysis. Int J Manage Educ. 2021;19(3):100545.
41. Larsson G, Sandahl C, Söderhjelm T, Sjövold E, Zander A. Leadership behavior changes following a theory-based leadership development intervention: A longitudinal study of subordinates' and leaders' evaluations. Scand J Psychol. 2017;58(1):62–8.
42. Helaly SH, Alenezi A, Elsabahy HE, Saleh MSM. Effects of head nurses' leadership behaviors and social intelligence on staff nurses' job involvement. Egypt J Health Care. 2022;13(4):1308–22. https://doi.org/10.21608/ejhc.2022.143963.
43. Jahani S, Babazadeh M, Haghighi SH, Ayesteh, Cheraghian B. The effect of entrepreneurship education on self-efficacy beliefs and entrepreneurial intention of nurses. J Clin Diagn Res. 2018;12(6):18–21.
44. Peláez Zuberbuhler MJ, Salanova M, Martínez IM. Coaching-based leadership intervention program: A controlled trial study. Front Psychol. 2020;10:3066.
45. Otache I, Umar K, Audu Y, Onalo U. The effects of entrepreneurship education on students' entrepreneurial intentions: A longitudinal approach. Educ + Train. 2021;63(7/8):967–91.
46. Bagheri A, Akbari M. The impact of entrepreneurial leadership on nurses' innovation behavior. J Nurs Scholarsh. 2018;50(1):28–35.
47. Li C, Makhdoom HUR, Asim S. Impact of entrepreneurial leadership on innovative work behavior: examining mediation and moderation mechanisms. Psychol Res Behav Manage. 2020;105–18.
48. Aboelyazid WA, Diab GM, Elshall SE. The relation between entrepreneurial leadership and innovative work behavior among nurses at menoufia university hospital. Menoufia Nurs J. 2024;9(4):171–89.
49. Saleh MSM, El-Gilany AH, Abdelhamid ZN, Hamed SA, Elsabahy H. Effect of authentic leadership training program of head nurses on creativity and motivation of nursing staff. Egypt J Health Care. 2021;12(3):600–14.
50. Abd ElKareem M, Basuony N, El-Rahman Mohamed A, Abdelhamid Hassanin MM, F., Mohamed H, S. Effect of the training program on nurses' performance regarding surgical wounds management. Egypt J Health Care. 2023;14(3):46–73.
51. Shetaia A-EA-E, Mostafa Ragheb S, Mohamed MS, S., Ghonaem EL-S, S. Effect of training program on nursing performance regarding emergency management of acute myocardial infarction patients. J Nurs Sci Benha Univ. 2023;4(1):95–113.
52. Elhabashy S, Moriyama M, Mahmoud EIED, Eysa B. Effect of evidence-based nursing practices training program on the competency of nurses caring for mechanically ventilated patients: a randomized controlled trial. BMC Nurs. 2024;23(1):225.
53. Hassan Mohamed M, Senousy AE, T., Mohamed Maarouf D. Effect of intervention program on nurses' performance regarding care of patients with heart failure. Egypt J Health Care. 2024;15(1):1087–99.
54. Soyal B. The relationship between corporate entrepreneurship and innovation and the moderating effect of transformational leadership (Master's thesis, Middle East Technical University). 2020.
55. Liu HY. Promoting creativity of nursing students in different teaching and learning settings: A quasi-experimental study. Nurse Educ Today. 2022;108:105216.
56. Aqtash S, Alnusair H, Brownie S, Alnjadat R, Fonbuena M, Perinchery S. Evaluation of the impact of an education program on self-reported leadership and management competence among nurse managers. SAGE Open Nurs. 2022;8:23779608221106450.
57. Okure DU. Impacts of organisational culture on academic efficiency and productivity in selected private universities in the Niger delta region of Nigeria. High Educ Q. 2023;77(2):298–310.
58. Lillsjö E, Bjuresäter K, Josefsson K. Registered nurses' challenges and suggestions for improvement of their leadership close to older adults in municipal home healthcare. BMC Nurs. 2023;22(1):80.

Publisher's note