

Developing an Instrument to Measure Penetration of Lean Thinking For Frontline Nursing Staff

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Abstract: **Background** Lean thinking and management are continuous improvement management plan that design the work flow to produce improvements in safety, quality and productivity. **Aim:** to develop an instrument to measure penetration of lean thinking for frontline nursing staff. **Methods:** A methodological mixed research design was utilized in all hospitals that are affiliated to the Ministry of Health and Population at El-Beheira Governorate (n= 21). **Subjects:** **Jury group** (n=55), divided into two groups: academic experts (n=10) and clinical/professional experts (n=45). **Tools:** tool one: Frontline Lean Thinking (FLT) Instrument and tool two: opinionnaire sheet and a demographic data sheet for study subjects. The tool development was executed based on five steps: (1) Content domain specification; (2) Item pool generation; (3) Face & content validity evaluation; (4) Reliability assessment; lastly, (5) Instrument refinement. **Results:** The study findings revealed that the majority of expert groups agreed on the final version of the developed FLT Instrument with the three levels, namely: organization, unit and individual with its ten sub-domains. **Conclusion:** the overall result from panel of experts: both academics and clinical/professional experts showed that the developed FLT Instrument has face and content validity. Moreover, the internal consistency reliability of the developed FLT Instrument illustrated good reliability. **Recommendations:** implementing the valid and reliable developed tool for measuring lean thinking penetration in different health care settings; conducting continuous periodic training programs for frontline nursing staff in different healthcare units; performing baseline assessment followed by yearly lean thinking penetration assessment; tracking changes in unit performance after implementation of a lean intervention that may give insight into quality of care; and contacting customer to report on improvements and apply the essence of lean thinking.

Keywords: Instrument development, Lean thinking, Frontline nursing staff.

I. Introduction:

Healthcare organizations encounter vital challenges, including fast increase in demands in relation to patients' numbers, expectations of quality, decrease waiting times and expensive treatments application. At the same time, they also need to use limited resources effectively and efficiently to face the constrained budgets⁽¹⁾. Recently, the implementation of lean approaches within health care operations have received growing popularity in diverse healthcare organizations, as a possible answer to challenges presented^(2, 3). Since Lean thinking or lean management is one of the contemporary management systems in health care⁽⁴⁾. Lean thinking is mainly focusing on customer value and "waste free" smooth processes⁽³⁾. Lean management is a blend of tools and practices designed to eradicate waste by decreasing variations in processes. It is founded in long-term continuous improvement philosophy, detailed root-cause analysis for problem solving, process flow efficiency, and development of individuals that over appreciate the time⁽⁵⁾.

Many positive prospects for lean thinking in healthcare because it firstly places the patient, decreases errors and provides chance for health care professionals to efficiently redesign their work without need for additional resources⁽⁶⁾. The most mutual areas in healthcare lean thinking penetration are functions that are process-oriented, where the most significant targets were time-saving and queuing time⁽⁷⁾. Another core target has been cost reductions and augmentation of productivity. Moreover, Lean thinking focus on quality and error reduction with achieving higher patient satisfaction⁽⁸⁾. The definite lean approaches scope in healthcare varies from a narrow focus from waste elimination to some extent greater focus, that additionally to waste elimination, encompasses minimizing variation in process, and working conditions improvement⁽⁶⁻⁸⁾.

Lean thinking emphasizes on the production approach and is founded directly on the actual activity; whereas being directed towards highlighting the need of value-added activities; thus, lean thinking leads to the elimination of waste and non-value-added processes for customers⁽⁹⁾. Lean thinking also involves a systematic method that authorizes the identification and exclusion of waste in the processes of production, focusing principally on total quality and bringing to the customer only what is of value⁽¹⁰⁾. Similarly, lean is value maximization for the customer through an efficient process without waste. In health care, this means providing services that satisfy and meet the needs and preferences of the patients^(11, 12). Another principle is the

elimination of activities that do not create value, along with any waste (long waits for care, duplicated procedure, conflicting advice regarding treatment). Such waste does not permit that the care process and treatment occur without interruption, diversions, returns or delays. Thus, with the elimination of these issues, the efficiency of activities and quality of service simultaneously increase⁽¹³⁾.

In the healthcare service, the aspects valued by the patients include: better, faster, safer, qualified and decisive nursing care, according to their needs, targeting for their full recovery and well-being^(14,15). Health care improvement provided in all healthcare surroundings has occurred early, in order to improve the effectiveness of activities and provide quality support to the patients receiving nursing services⁽¹⁶⁾. Health care lean application focus on the patient and includes comfort and time, as key performance measures of the system⁽¹⁷⁾. Lean thinking is a management model that has arisen as a reference for the scope of this high-quality care, commonly with continuous improvement of the processes involving the nursing at the frontline⁽¹⁸⁾. Frontline nursing staff's perceptions of what is needed to change, to create new task rather than just destroying jobs in the name of efficiency, with focusing on some lean tools, such as: value stream map, zero defects, continuous improvements and JiT (Just in Time) in healthcare, lean production will be applicable⁽¹⁷⁾. Additionally, lean thinking can be seen as the outcome or product of the lean innovation in any healthcare organization, which involves training nurses at the frontline on how to improve performance under the guidance and direction of a mentor, to become aware of problems and to note where the system falls out of perfection, then persistently track the resolution of these problems every day^(19, 20).

Frontline nursing staff involvement in patient care activities is vital to lean thinking's effectiveness, especially at nursing unit-level decision that is confirmed with their common response to problems by using techniques that allowed them to continue patient care and provide value as defined by their customer, which is considered the essence of lean philosophy^(18, 21-23). Nursing frontline have resources and accurate information available to perform timely and correctly care processes, and to take needed action if the work system fails⁽²²⁾. Moreover, they use operational failures as triggers for process improvement that is very beneficial to health care organization^(18, 21, 22). The penetration of lean thinking by the frontline nursing staff is evaluated through three levels: organizational, unit and individual⁽²⁴⁻²⁶⁾. In relation to organizational level, organizational structure and capacity for new knowledge are antecedents for any desired innovation; and organizational system readiness defines a culture that is ready for and conducive to change. It is also related to the organization's openness to change; leadership; work climate; receptive management; clear goals and capacity for collecting high-quality data are persuasive forces behind the lean thinking^(24,25). Organizational level encompassed two sub-domains, namely: **educational organization**: in which every staff nurse in the organization is encouraged to get drill and training on improving processes with many opportunities to learn about process improvement; and **frontline participation**: as leaders in the organization promote frontline nurses participation in problem-solving and help them to better understanding of problems⁽²⁵⁾.

As for unit level, lean thinking penetration includes the amount of time devoted to improvements and the available resources, such as: trainers, mentors and costs for developing staff as influencers of lean thinking. Other unit level traits include: monitoring; guidance; team decision-making; leaders and managers' attendance; training; and effective communication and collaboration. Additionally, further influencers for lean thinking penetration encompass: social networks; similarity of team members; and peer opinions and change agents. Thus, to measure lean thinking penetration, user involvement; active knowledge transfer; common meanings and mission and user-led innovation should be considered. Orientation of users; project management; technical support and communication of information also contribute to effective lean thinking penetration⁽²⁴⁻²⁶⁾. Unit level included three sub-domains, as follows: **supervisor support**: as managers are interested in new ideas and their meetings with nurses are efficient and focused; **mentoring**: as there is a frequent guidance and directing to teach nurses about process improvements, and availability of lean mentors to help them in identifying errors that might occur in their work; and finally, **patient-centered focus**: as patient care is completed in a systematic way, utmost nurses recognize that what they do is for the sake of their patients and they are usually able to give them what they want, when they want it, in the way they expect it, as long as safety is not compromised⁽²⁵⁾.

In respect to individual level, patterns of lean thinking penetration confirmed that individuals display many of the similar characteristics and certain attributes as: being innovators; early adopters; with more formal education; higher social status; contacts with diverse change agents; and greater social participation with exposure to interpersonal channels of communication. Qualities that are linked to lean thinking adoption include: individual needs; motivators; values; goals; learning style and social networks. Other factors affecting lean thinking penetration include: organized process of problem-solving; brainstorming with recognition of root causes of the problem; generation of creative improvement ideas and measures; and interprofessional communication. Individuals in a lean system often exhibit the traits associated with a deeper level of problem-solving^(25,26). Individual level consisted of five sub-domains, namely: **do action**: as nurses know the importance of confronting problems, not ignoring them, they plan to improve care, and they continually think of different ways to perform better nursing care; **solve problems**: as nurses identify methods to eliminate waste in patient

care, find ways to increase time with the patients and use problem-solving to remove hindrances to providing optimum patient care; **use improvement tools**: as nurses think of the importance of performing care in an innovative manner to other nurses in the organization and unit, which can be achieved through solving problems by using a methodical written, approach with improvements tools to communicate the ideas. **Catch opportunities**: they find opportunities to improve how they provide nursing care every work-day and compare the way they perform care to how their co-workers perform such nursing care. Finally, **attitude for change**: as they think that process improvements can cause positive outcomes and change to occur in this organization⁽²⁵⁾.

Many international studies focused on implementing lean tools⁽²⁷⁾; identifying lean parameters⁽²⁸⁾; assessing lean thinking⁽²⁹⁾; and applying lean healthcare program⁽³⁰⁾. A study was conducted, nationally up to researchers' knowledge, to apply lean tools in healthcare organizations through applying lean strategies training program; and concluded that lean strategies utilization training program implementation had positive effects on quality and environmental safety immediately after and after three months of program implementation⁽³¹⁾. Therefore, little is known about the extent to which lean thinking is applied in Egyptians health care settings, to be prepared for the accreditation requirements and the new health insurance system that will be executed soon. Therefore, this study is essential to develop an instrument for Frontline Lean Thinking (FLT), to measure the penetration of lean thinking in nursing staff through using lean methods. Using this measure of "leanness", in future studies can impact lean outcomes, such as: safety, quality, cost and delivery of care and their relationships to the amount of lean applied in healthcare organizations. It also aimed to assess applicability of lean to such an extent that it can contribute considerably to solving the challenges facing health care organizations regarding accreditation process.

Significance of the problem

Although lean thinking and management lead to better outcomes that has been extensively tested in other industries, studies of lean management in healthcare have lacked rigorous experimental methods. Some hospitals have labeled themselves as lean in their market, yet their quality indicators have not reflected better quality than hospitals that did not make this claim. Further, few of lean studies have focused on the processes carried out on the nursing unit, the important point of patient care. There are many stages and degrees of lean thinking and management in healthcare organizations or nursing units^(32,33).

To date, there is no validated instrument is available to measure Lean thinking penetration or diffusion in health care organizations. Therefore, determination whether lean thinking and management improves the quality, safety, cost and delivery of care cannot be judged. To find out whether lean thinking is the reason for better healthcare outcomes, a measure of lean is needed to capture the variation that may be responsible for better or worse outcomes. By identifying elements that should be found on a lean unit and comparing them to what is actually present on the unit, a measure of lean thinking penetration could identify gaps in care⁽⁴⁾.

Aim of the study

The aim of this study was to develop an instrument to measure penetration of lean thinking for frontline nursing staff.

Research hypotheses:

- The instrument developed to measure penetration of lean thinking for frontline nursing staff will be valid.
- The instrument developed to measure penetration of lean thinking for frontline nursing staff will be reliable.

II. Material and Methods:

Research Design

A methodological, mixed research design was utilized to conduct this study.

Setting

All hospitals that are affiliated to the Ministry of Health and Population at El-Beheira Governorate, were included in this study (n= 21). It includes: Edfina Central Hospital; Badr Central Hospital; Wadi El Natroun Central Hospital; HoushEissa Central Hospital; Rashid General Hospital; Abu Al Matamir Central Hospital; Idku General Hospital; Kom Hamada General Hospital; Damanhour Chest Hospital; Kafr El-Dawar General Hospital; Kafr El-Dawar Central Hospital; Kafr El-Dawar Fever Hospital; Damanhour Ophthalmic Hospital; El Rahmaneya Central Hospital; El Delengat Central Hospital; Abu Hummus General Hospital; El Mahmoudeya Central Hospital; Itai El Baroud General Hospital; Shubrakhit Central Hospital; Damanhour Fever Hospital; and El Noubareya Central Hospital.

Subjects

The subjects of this study included the following:

Panel of experts:

They were divided into:

- a. **Academic experts** (n=10): included academic staff from the related field of the study.
- b. **Clinical/professional experts** (n=45): included directors of nursing services and their assistants (n=42), who are working in the previously mentioned settings; additionally, the director of nursing administration at El-Beheira Directorate of Health Affairs and her assistants (n=3).

Tools of the study:

The following two tools were developed:

Tool (I): Frontline Lean Thinking (FLT) Instrument

It was developed by the researchers based on a thorough review of the related literature⁽²¹⁻³⁰⁾, to assess and measure lean thinking penetration for the frontline nursing staff, at different health care organization levels. It included three levels and its ten sub-domains, namely: (1) organization level: educational organization and frontline participation; (2) unit level: supervisor support, mentoring, and patient-centered focus; and lastly, (3) individual level: do action, solve problems, use improvements tools, catch opportunities and attitude for change.

Tool (II): Opinionnaire Sheet

This opinionnaire sheet was developed by the researchers to measure the panel of experts (both groups) opinions, in relation to the general form of the developed tool. Responses will be measured as agree or disagree. The higher percentages indicate better agreement on the general form of the developed tool.

In addition to that, a demographic characteristics data sheet of panel experts, was developed by the researchers, and included data, such as: age, years of nursing experience, educational qualification and marital status.

Methods:

1. An approval to carry out the study was guaranteed from the responsible authorities after explanation of the purpose of the study.
2. Development of the instrument was executed based on the following five steps:
 - (1) Content domain specification: to clearly define the intended instrument levels and its sub-domains for measuring lean thinking penetration of frontline nurses, after thorough review of related literature⁽²¹⁻³⁰⁾.
 - (2) Item pool generation: to generate statements/items. Sample of frontline nurses, who were willing to report their experiences about lean thinking penetration, were selected through face to face interview to gather information from the actual working environment. Constant comparative analysis between these two steps was carried out; afterwards, the **first version** of the developed instrument was available. It included three levels and its sub-domains (60 items), namely: (1) organization: educational organization (4-item) and frontline participation (3-item); (2) unit: supervisor support (9-item), mentoring (6-item), and patient-centered focus (9-item); and lastly, (3) individual: do action (4-item), solve problems (5-item), use improvements tools (9-item), catch opportunities (5-item) and attitude for change (6-item).
 - (3) Face & content validity evaluation: to determine the face and content validity of the first version of developed Frontline Lean Thinking (FLT) instrument, which was tested by a panel of both academic and clinical/professional experts. Each expert was individually asked to read and evaluate the relevance of each item to the main level and its sub-domains using a 4-point ordinal rating scale (1 = irrelevant, 2 = unable to assess the relevance without item revision, 3 = relevant with minor alterations, 4 = extremely relevant). They were asked to reflect on each item's measuring feasibility through a "yes" or "no" response. Revision involved checking items that are difficult to answer or understand and identifying vague words. Long sentences in measurement items decrease readability; therefore, longer items were revised in order to deliver sufficient meaning, while excluding unnecessary or vague words, yielding **second version** of Frontline Lean Thinking (FLT) instrument.
 - (4) Reliability assessment: the internal consistency reliability of the second version of the instrument was assessed using Cronbach's Alpha coefficient test and intra-class correlation coefficient, inter-rater and inter-term correlations (Fig. 1).
 - (5) Instrument refinement: based on the result of the reliability tests, the **final version** of the Frontline Lean Thinking (FLT) instrument was developed. It included three levels and its ten sub-domains (50 items), namely: (1) organization: educational organization (4-item) and frontline participation (3-item); (2) unit: supervisor support (**8-item**), mentoring (**4-item**), and patient-centered focus (**7-item**); and lastly, (3) individual: do action (4-item), solve problems (**3-item**), use improvements tools (9-item), catch opportunities (**3-item**) and attitude for change (**5-item**).

Data collection

The researchers distributed the questionnaires to study subjects. Data collection took six months, from September 2017 till February 2018.

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Fig. (1): The scoring of Cronbach's Alpha coefficient ⁽³⁴⁾.

Ethical considerations

- An Informed written consent was obtained from the study subjects after explanation of the aim of the study.
- The confidentiality and anonymity were assured through assigning a code number for each staff nurse instead of names to protect their privacy.
- The right to withdraw from the study has been guaranteed at any time.

Statistical analysis: Data were collected, tabulated, statistically analyzed using an IBM personal computer with Statistical Package of Social Science (SPSS) version 22. The following statistics were applied. **1. Descriptive statistics:** in the form of frequencies, percentages, mean and standard deviation. **2. Validity of developed tool:** was assessed statistically by exploratory factor analysis. **3. Reliability of developed tool:** was calculated through Cronbach's Alpha coefficient test and intra-class correlation coefficient, inter-rater and inter-term correlations.

III. Results

Table 1 demonstrated that the mean age of academic and clinical/professional expert groups are 34.91 ± 5.8 and 36.31 ± 6.9 , respectively. Moreover, this table revealed that all academic group hold doctor degree; compared to 44.4% of clinical/professional experts, who hold master's degree. This table also showed that the mean years of nursing experience of academic and clinical/professional experts are 16.4 ± 7.9 and 18.23 ± 6.94 , respectively. According to the marital status, the highest percentage of both academic and clinical groups were married (80%, 86.7%), consecutively.

Table 2 mentioned that all academic group and the majority of clinical/professional group accepted the developed Frontline Lean Thinking (FLT) Instrument, for face validity. A significant difference was found between both groups ($P= 0.041$).

Table 3 (a, b and c) stated that there is good internal consistency for the majority of items of lean thinking penetration instrument at the three levels: organization, unit and individual with its ten sub-domains; however, there are only five items has questionable internal consistency.

Table 4 indicated that there is nearly excellent internal consistency for the total developed Frontline Lean Thinking (FLT) Instrument; organizational, unit and individual levels; and its ten sub-domains (0.899).

Table 5 showed that the developed Frontline Lean Thinking (FLT) Instrument, at 99% confidence interval of the intraclass correlation was 0.987, indicating an excellent reliability.

Table 6 proved that there were positive significant correlations between the ten sub-domains of the developed Frontline Lean Thinking (FLT) Instrument.

Table 7 showed that there were highly positive significant correlations between levels of the developed Frontline Lean Thinking (FLT) Instrument, with each other at p value <0.01 .

Table (1):Distribution of the panel of experts (academic and clinical/professional), according to demographic characteristics.

Demographic Characteristics	Expert groups (N = 55)			
	Academic (N=10)		Clinical/professional (N=45)	
	No.	%	No.	%
Age				
20 - <30	0	0	5	11.1
30 - <40	12	60	22	48.9
≥ 40	8	40	18	40.0
Mean \pm SD	34.91 ± 5.8		36.31 ± 6.9	

Demographic Characteristics	Expert groups (N = 55)			
	Academic (N=10)		Clinical/professional (N=45)	
	No.	%	No.	%
Educational Qualification				
Bachelor of Nursing Sciences	0	0	22	48.9
Master of Nursing Sciences	0	0	20	44.4
Doctor of Nursing Sciences	10	100	3	6.7
Nursing Experience (years)				
5 -<15years	5	50	6	13.3
15 -< 25 years	3	30	22	48.9
≥25 years	2	20	17	37.8
Mean±SD	16.4±7.9		18.23±6.94	
Marital Status				
Married	8	80	39	86.7
Not Married	2	20	6	13.3

Table (2): Agreement of jury expert groups on general form of the preliminary tool (Face Validity) of the developed Frontline Lean Thinking (FLT) Instrument.

Items	Expert groups (N =55)				Friedman test	
	Academic (N = 10)		Clinical/professional (N = 45)		x ²	P.value
	No.	%	No.	%		
1. The tool looks like assessment of frontline lean thinking management.	10	100	43	95.5	7.211	.041*
2. Demographic characteristics and data sheets are enough.	9	90	45	100		
3. The tool items are relevant to its title, levels and sub-domains.	10	100	44	97.7		
4. The tool format includes items representative for every sub-domain.	9	90	45	100		
5. The numbers of sub-domains and its items are suitable for the developed tool.	10	100	42	93.3		
6. The statements of items are considered clear, specific and understandable.	10	100	43	93.3		

*Significant at P< 0.05

Table (3a): Total reliability analysis of items of the developed Frontline Lean Thinking (FLT) Instrument (organization level and its sub-domains).

Organization Level and Its Sub-domainsItems	Mean	SD	Alpha of item deleted
Educational Organization			
1. Everyone is encouraged to get training.	4.225	0.245	0.978
2. Nurses are expected to attend classes.	3.45	0.651	0.776
3. There are many opportunities to learn.	3.60	0.170	0.871
4. Organization stresses continuing education is important.	4.97	0.029	0.843
Frontline Participation			
5. Mission of the organization helps guide change	3.74	0.160	0.901
6. Leaders of the organization include frontline staff like me.	4.79	0.210	0.819
7. A hospital leader comes to the unit to help understand the problem.	3.901	0.009	0.811

Table (3b): Total reliability analysis of items of the developed Frontline Lean Thinking (FLT) Instrument (Unit level and its sub-domains).

Unit Level and Its Sub-domainsItems	Mean	SD	Alpha of item deleted
Supervisor Support			
8. My supervisor’s attitude helps get everyone involved.	4.07	0.253	0.904
9. My supervisor follows-up to find ways for work improvements.	3.919	0.221	0.879
10. My supervisor encourages new ways of doing things.	4.20	0.400	0.809
11. My supervisor is receptive to new ideas.	4.00	0.310	0.786
12. My supervisor creates new ways of seeing the problem.	3.991	0.109	0.791
13. Staff meetings are focused.	2.419	0.149	0.673*
14. My supervisor comes to help searching for the causes of the	3.641	0.150	0.900

Unit Level and Its Sub-domainsItems	Mean	SD	Alpha of item deleted
problem.			
15. My supervisor identifies “work-arounds.”	3.221	0.679	0.841
16. My supervisor asks staff to use a written plan.	4.462	0.170	0.873
Mentoring			
17. My mentor helps me recognize errors in my work.	4.712	0.288	0.874
18. My mentor helps me recognize that errors.	3.011	0.899	0.819
19. My mentor is available to coach staff.	3.123	0.861	0.879
20. Designated mentor who helps work through problems.	4.341	0.607	0.872
21. Availability of education programs that teach nurses.	1.791	1.521	0.666*
22. Nurses worked on at least one improvement project under mentor supervision.	1.689	1.403	0.656*
Patient-Centered Focus			
23. There are ways to measure time spent in patient care.	3.991	0.001	0.889
24. Supplies are in a designated place.	3.711	0.121	0.871
25. Patient care is performed in a systematic way	4.341	0.607	0.872
26. Nurse is able to give the patients what they want.	3.191	1.121	0.866
27. Patient care is a team effort.	2.979	1.303	0.856
28. Stocks of supplies are sufficient.	2.00	0.071	0.689*
29. Equipment is kept in a designated, safe place.	4.141	0.121	0.871
30. Supplies needed to do the work are available.	2.00	0.907	0.671*
31. Cleanliness and order are monitored.	4.462	0.775	0.878

* Omitted items

Table (3c): Total reliability analysis of items of the developed Frontline Lean Thinking (FLT) Instrument (Individual level and its sub-domains).

Individual Level and Its Sub-domains Items	Mean	SD	Alpha of item deleted
Do Action			
32. I Need to look for ways to improve patient care.	4.712	0.551	0.976
33. I can decrease cost of care by using the needed supplies.	3.011	0.420	0.881
34. I must think of ways to perform better care.	4.462	0.260	0.891
35. I must make sure that care delivered is error-free.	3.79	0.210	0.989
Solve Problems			
36. I found it is important to confront problems, not ignore them.	3.123	0.329	0.893
37. I inform the patient of the expected routine care.	3.991	0.009	0.891
38. I carry out, analyze and improve the plan of care delivered to patients.	2.047	0.253	0.500*
39. It is important to find out why the system created an error.	1.789	0.221	0.546*
40. I look at the start of the process till it finishes before finding solutions	3.901	0.000	0.976
Use improvements Tools			
41. I identify ways to eliminate wastes.	4.07	0.000	0.881
42. I reduce waste in wait time and over-processing.	3.919	0.009	0.893
43. I increase time spent with the patient.	4.200	0.199	0.891
44. I address issues before an error occurs.	4.001	0.450	0.989
45. I eliminate delays, errors and inappropriate procedures.	4.225	0.775	0.841
46. I remove obstacles to optimum patient care	3.453	0.551	0.873
47. I try to make patient care safer	3.600	0.420	0.874
48. I do everything with a patient focus.	4.971	0.329	0.819
49. I continually find ways to perform patient care better.	4.225	0.260	0.879
Catch Opportunities			
50. I call managers (stop-the-line) during a shift.	2.041	0.607	0.592*
51. I look for ways to keep searching for new methods.	1.891	1.121	0.566*
52. I start the plan for discharge on the day of admission.	3.679	1.303	0.856
53. I perform care like nurses in the organization.	4.919	0.031	0.889
54. I perform care like nurses on the unit	3.841	0.121	0.871
Attitude for Change			
55. I sketch out a diagram of how care is currently carried out.	3.841	0.607	0.976
56. I map what actions occur during patient care.	4.891	1.121	0.881
57. I use systematic, written approach to communicate	4.079	1.303	0.903
58. I find opportunities to improve care.	3.199	0.091	0.791
59. I compare ideal care with the actual care performed.	3.741	0.121	0.789
60. I save time when problems are worked on as they occur	1.920	0.887	0.571*

* Omitted items

Table (4): Total reliability analysis of levels of lean thinking and its sub-domains of the developed Frontline Lean Thinking (FLT) Instrument.

Levels of lean thinking and its sub-domains	No. of items	Alpha Cronbach	F	P-value
Organization	7	0.933	3.91	.000
Educational organization	4	0.880	3.47	.001
Frontline Participation	3	0.900	2.80	.002
Unit	19	0.901	9.31	.001
Supervisor support	5	0.799	5.34	.003
Mentoring	6	0.845	4.99	.000
Patient-centered focus	8	0.913	6.31	.001
Individual	24	0.786	11.47	.000
Do Action	7	0.912	8.36	.000
Solve problems	7	0.897	7.94	.001
Use improvement tools	4	0.811	3.19	.002
Catch opportunities	2	0.974	2.34	.002
Attitude for change	4	0.897	3.71	.001
Total	50	0.899	23.740	.000

**highly significant at P<0.01

Table (5): Inter-rater reliability of the developed Frontline Lean Thinking (FLT) Instrument.

Items	Frontline Lean Thinking (FLT) Instrument
Intraclass Correlation (ICCs)	.987
At confidence interval 99%	
P value	.000

**highly significant at P<0.01

Table 6: Inter-term correlation between items of the developed Frontline Lean Thinking (FLT) Instrument.

Lean thinking sub-domains		Educational organization	Frontline Participation	Supervisor support	Mentoring	Patient centered focus	Do Action	Solve problems	Use improvements tools	Catch opportunities	Attitude for change
Educational Organization	R Sig.	.975 .000	.876 .000	1.210 .020	.475 .000	.548 .002	.984 .000	.721 .001	.641 .000	.311 .000	.975 .001
Frontline participation	R Sig.	.745 .001	.212 .000	.094 .002	2.21 .005	3.21 .009	.645 .000	.375 .001	.653 .002	1.211 .001	.974 .000
Supervisor support	R Sig.	.631 .001	.934 .000	.244 .002	1.022 .010	.311 .003	.811 .000	.744 .001	.439 .002	.661 .003	.912 .000
Mentoring	R Sig.	.901 .000	.231 .002	0.451 .002	.711 .001	.888 .000	.741 .000	.621 .001	.321 .012	.688 .000	.941 .000
Patient centered focus	R Sig.	.375 .001	.653 .002	1.211 .001	.974 .000	.975 .000	.876 .000	1.210 .020	.475 .000	.389 .001	.965 .000
Do Action	R Sig.	.112 .040	.345 .003	.256 .013	.0954 .000	.756 .001	.843 .002	.969 .000	.703 .002	.697 .001	.965 .000
Solve problems	R Sig.	.741 .000	.621 .001	.321 .012	.688 .000	.631 .001	.934 .000	.244 .002	1.022 .010	.876 .000	1.210 .020
Use improvements tools	R Sig.	.365 .009	.698 .004	1.02 .032	2.32 .041	.987 .000	.861 .000	.654 .001	.777 .002	.846 .001	.946 .000
Catch opportunities	R Sig.	0.945 .001	0.675 .024	0.741 .005	0.843 .006	0.936 .000	0.965 .000	1.09 .010	2.31 .032	0.832 .003	0.703 .008
Attitude for change	R Sig.	0.451 .002	0.711 .001	0.888 .000	0.741 .000	0.645 .003	0.375 .001	0.653 .001	0.231 .023	0.451 .002	0.931 .000

*Significant at P< 0.05; **highly significant at P<0.01

Table (7): Correlation matrix between total levels of the developed Frontline Lean Thinking (FLT) Instrument.

Frontline Lean thinking levels	Organization	Unit	Individual
Organization		R .467 Sig .000**	R .717 Sig .002**
Unit	R .671 Sig .000**		R .870 Sig. 000**
Individual	R .592 Sig .009**	R .908 Sig. 001**	

**highly significant at P<0.01

IV. Discussion

Lean thinking, a method of quality improvement in healthcare is receiving increased attention. Quality improvement projects using lean management elements are common in the healthcare literature ⁽⁴⁾. Measuring the amount of lean thinking penetration in hospitals is the first step toward connecting the amount of lean thinking management to promising outcomes for hospital improvements in quality, safety and cost. This measure of lean in healthcare will help to target lean improvements in hospitals or nursing units, the most important point of customer contact ^(5, 12, 35). Consequently, the findings of this study illustrated that this developed tool is considered a reliable and valid tool to measure lean thinking penetration for the hospital frontline nursing. The face and content validity; as well as the reliability of the Frontline Lean Thinking (FLT) Instrument was confirmed by both jury groups, experts and health care professionals.

Regarding face validity, all academic group and the majority of clinical/professional group accepted the developed FLT Instrument, with a significant difference found between both groups. They agreed on relevance of items to the instrument title and its sub-domains; adequacy of the number of levels and sub-domains and representativeness of items in each sub-domain with specificity and clearance of statements. This may be due to that the thorough review of related literature, considered the whole parts of the lean thinking penetration of the frontline nursing staff members, was effective. This is in line with Polit and Beck (2012)⁽³⁶⁾, who stated that the panel of nursing experts were used to evaluate the face validity of the developed scale and its individual items to assess it in terms of the intelligibility and relevance of the items. Face validity is important for developed instrument, this is supported by Deveon et al. (2007)⁽³⁷⁾, who confirmed that face validity assessments provided vision and insights into how potential participants may interpret, infer and answer the items because it is an evidence that the scale truly measures and relevant to measure the intended assessments.

Concerning content validity, experts judged that the content accurately captures and measures each level and its related sub-domains. This may be because of the variety of experts (academics and professional/clinical) participated and their valuable inputs. The experts' input confirmed that the conceptual framework of the study was practical and reasonable; therefore, it could serve as a starting point for measuring lean thinking penetration for frontline nursing staff members at hospital settings. This is supported by Fitzpatrick and Kazer (2012)⁽³⁸⁾, who confirmed that validity refers to the accuracy of responses on self-reported measures of attitudes and behaviors; and that content validity determines whether the items sampled for inclusion adequately represent the domain of content addressed by the instrument's main objective, which is done by a panel of experts, that include professional experts or members of the target population; whereas, face validity, clarify if the developed instrument looks as if it measures what it says it measures ⁽³⁸⁾.

As regards tototal reliabilityof FLT, there is nearly excellent internal consistency for the overall organization, unit and individual levels. This result can be justified because lean thinking penetration management follows an expected pattern: from organization, to unit, and finally, to individuals, which subsequently could be more iterative or circular. Moreover, organizational mission and leadership start the process, and then, unit managers inspire nurses to adopt lean thinking and management at their working settings. At the end of the process comes the nurse, as an individual, who adopt lean thinking and become more important as mentors or coaches or leaders, who are rewarded to create spread or high penetration of lean thinking and management strategies. This goes in line with Fitzpatrick and Kazer (2012)⁽³⁸⁾, who defined reliability as the consistency of responses on self-report, norm-referenced measures of attitudes and behaviors; and that Cronbach's Alpha reliability coefficient is the most predominant technique for assessing internal consistency, with the values closer to 1 indicating less measurement error; and that a well-developed instrument must demonstrate a coefficient value above .80 ⁽³⁸⁾. This is supported by Hessler and Humphrys (2008), who mentioned that, in order to use any tool, validity and reliability, should be done ⁽³⁹⁾.

Pertaining to the final version of the developed tool, it is noticed that at the organization level with its two sub-domains: educational organization and frontline participation, all items were retained. As for the unit level and its three sub-domains, the omitted items were as follows: supervisor support "Staff meetings are focused"; mentoring "Availability of education programs that teach nurses" and "Nurses worked on at least one improvement project under mentor supervision"; and finally, patient-centered focus "Stocks of supplies are

sufficient” and “Supplies needed to do the work are available”. Lastly, regarding individual level and its five sub-domains, the omitted items were, namely: do action (no omitted items), solve problems “I carry out, analyze and improve the plan of care delivered to patients” and “It is important to find out why the system created an error; use improvements tools (no omitted items), catch opportunities “I call managers (stop-the-line) during a shift” and “I look for ways to keep searching for new methods”; and attitude for change “I save time when problems are worked on as they occur”. This may be due to the panel of experts (either academic or professional), who viewed the developed tool based on the presence of these items at the actual daily working environment. Moreover, they considered these omitted items as low reliable, which may be due to the inapplicability of the omitted items at the hospital settings, as the items are not feasible at the frontline level. This is in line with Andersen et al. (2014)⁽⁴⁰⁾, who found that experts portrayed that items retained were related to leaders of lean organization, who communicated the vision and mission of patient-centered and waste-free care, to stimulate new ways of thinking about processes and doing the work. Additionally, the experts' descriptions of lean management encompassed both physical features and thinking patterns of nurses at unit level. Finally, the experts viewed the availability of lean thinking at individual level, who educate and manage resources to support lean improvement ideas. Individual nurses in a lean hospital know how to draw a process map and use it to find new ways to increase time with the patient. They would look for things that unnecessarily cost the patient money, time, and physical comfort or anything described as ‘waste’ in lean thinking. Nurses would have time to work on creating value for their patient-customer⁽⁴⁰⁾.

Furthermore, there was a highly positive significant correlation between the three levels of lean thinking penetration instrument and a positive significant correlation between the ten sub-domains with each other. This result can be justified as there is significant differences between all ten sub-domains of the developed FLT, namely: educational organization; frontline participation; supervisor support; mentoring; patient-centered focus; do action; solves problems; use improvements tools; catches opportunities and attitude for change. This is in line with Holden (2011)⁽⁴¹⁾, who mentioned that numerous process changes and improve patient care, often including distinct patient flow and streams, after lean thinking followed by implementation of lean strategies. The success factors of lean approach included involvement and participation of employees, preparedness for change and management support⁽⁴¹⁾. Moreover, Francis (2014)⁽⁴²⁾ confirmed that lean thinking requires a high level of organizational investment, including an investment in culture of education and mentoring, to guarantee and ensure lean success. This literature highlights linkages between lean, organizational learning and mentoring and presents recommendations about how institutions can plan and assess lean improvement initiatives⁽⁴²⁾.

Additionally, solving problems and do actions are considered as vital elements of lean thinking because it is concerned with finding out the root causes of problems, that requires real-time, accurate and observational data collection⁽⁴³⁾. As lean thinking in healthcare usually is closely associated with observational data collection rather than the traditional data collection methodologies. As data collected by staff observation, result in a more apparent need for change and urgency for healthcare processes and making recommendations to organizations, permitting instantaneous root-cause analysis, quick feedback, prompt action and a feeling of contribution amongst those who participated⁽⁴⁴⁾. This is also supported by Andersen et al. (2014)⁽⁴⁰⁾, who emphasized this approach, as accurate data and team involvement were among the most important facilitating and enabling factors for the lean initiative, as there is a need for actual, evidence-based data in health care management.

Moreover, this is in line with Simon (2012)⁽⁴⁵⁾ and Chiarini (2013)⁽⁴⁶⁾, who demonstrated through a qualitative case study how particular tools derived from lean thinking such as value stream mapping and activity worksheet can help to reduce costs related to patient transportation and other kinds of wastes^(45, 46). This is also consistent with Decker and Stead (2008)⁽⁴⁷⁾, who concluded that the primary focus of applying lean is the patient; thus, it appears that the increasing embrace of lean thinking and related methodologies to the health care environment is necessary and results in improved patient care metrics, greater efficiency, and ultimately happier and healthier patients⁽⁴⁷⁾. Lastly, Kim et al. (2009)⁽⁴⁸⁾, summarized that the following factors were found to be key to Lean project success, namely: expert guidance for initial efforts; supervisors' support; frontline nurses participation and engagement in changing “current state” processes; identifying waste and find opportunities for designing an improved “future state”; using unified metrics with limited differences to develop and track interventions; and defining realistic lean project scope⁽⁴⁸⁾.

V. Conclusion

It is concluded that the overall result from panel of experts: both academics and clinical/professional experts showed that the developed Frontline Lean Thinking (FLT) Instrument has face and content validity. Moreover, the internal consistency reliability of the developed Frontline Lean Thinking (FLT) Instrument was assessed using Alpha Cronbach's co-efficient test and intra-class correlation co-efficient, inter-rater and inter-term correlations, which illustrated good reliability.

VI. Recommendations

In light of the study findings, it is recommended that:

Hospital administrators should:

- Implement the valid and reliable developed tool for measuring lean thinking penetration in different health care settings (Ministry of Health hospitals in other governorates; private and public hospitals).
- Conduct continuous periodic training programs for frontline nursing staff in different healthcare units, to increase their awareness about lean thinking and management.
- Perform a baseline assessment followed by a yearly lean thinking penetration assessment to help healthcare organizations or units endorse strategies that ensure improvement efforts are sustained.
- Encourage improvement of tools for monitoring performance through applying lean measures, by the developed instrument, at the organization, unit and individual levels to capture the quality of leanness and, by extension, lean penetration to the frontline.
- Measure the success of lean improvement program through the organization's final 'product' -the patient-to evaluate if the organization's lean management, or other quality improvement, initiative has reached the level of care.

Staff nurses should:

- Evaluate their units within the hospital and identify areas to focus resources and programs for team alignment with organizational strategic priorities.
- Track changes in unit performance after implementation of a lean intervention that may give insight into quality of care.
- Understand their own way of thinking that provides a way to identify mentors and coaches as well as change agents.
- Contact with the customer to report on improvements and apply the essence of lean thinking, i.e. to provide value as defined by the customer, through every sub-domain that address key elements of lean thinking; consequently, give ideas about specific opportunities for enhancing quality measures.

Future researches

- Replication of this study in private hospitals that claim applying lean strategies to provide comparative design.
- Apply the developed Frontline Lean Thinking (FLT) Instrument in different health care organizations.
- Identifying factors affecting lean thinking penetration in hospitals.

Strengths and Limitations

The strengths of this study included the presence of panel of experts with their valued point of view and feedback that captured a range of nursing related lean thinking concepts. Another strength of the study was the idea itself; as it was the first-attempt to develop a Frontline Lean Thinking (FLT) Instrument in the health care settings, to increase the knowledge and behaviors of nursing in order to improve awareness about lean thinking. It shed light on the importance of these initiatives for health care quality and safety. However, few limitations exist in this study, as generalization is limited to Ministry of Health hospitals at El-Beheira governorate.

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