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Development and validation of a safety leadership Self-Efficacy Scale (SLSES) in maritime context

Tae-eun Kim [a,*], Are Kristoffer Sydnes [b], Bjørn-Morten Batalden [b]

[a] Department of Maritime Operations, Faculty of Technology, Natural Sciences and Maritime Sciences, University of South-Eastern Norway (USN), Norway
[b] Department of Engineering Science and Safety, Faculty of Science and Technology, UiT-The Arctic University of Norway, Norway

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A B S T R A C T

Extensive studies have highlighted the importance of leadership on safety in the maritime industry. However, current research lacks empirically tested theoretical models with valid and reliable scales for describing and measuring safety leadership in ship operations. This study reports the development and validation process of the first *Safety Leadership Self-Efficacy Scale* (SLSES) for assessing shipboard officer's efficacy in exercising leadership for safety in merchant shipping. The research has been divided into three stages, including a content validation study (20 subject matter experts), an Exploratory Factor Analysis (EFA) ($n = 150$) and a Confirmatory Factor Analysis (CFA) ($n = 396$). The results have supported a higher order factor structure with three subscales – motivation facilitation, safety management and safety initiative – contributing to the measurement of safety leadership self-efficacy. The resulting scale has revealed adequate measurement properties with good explanatory power, construct validity and high internal reliability (Cronbach's $\alpha = 0.971$). SLSES can provide maritime researchers, practitioners and shipping organizations with a tool to assess and enhance safety leadership potentials of current and future shipboard officers. The theoretical, methodological and practical implications of SLSES were discussed.

1. Introduction

Although the maritime industry has gone to great lengths to enhance safety by promulgating safety rules, regulations and standards, unanticipated – and sometimes catastrophic – accidents still occur (Schröder-Hinrichs et al., 2012; Batalden and Sydnes, 2014; Kim et al., 2016). Lessons learned from accidents (e.g., Costa Concordia, Sanchi, Sewol ferry, Bow Mariner) have consistently observed the important role of human element, especially leadership and management practice for safety (Grech et al., 2008; Kim et al., 2016). A well-functioning Safety Management System (SMS), good accident prevention activities and active safety communications cannot be envisioned without the existence of strong leadership and management support (O'Dea and Flin, 2001; Kim and Gausdal, 2017). As Leveson (2011) put it, "Safety starts with management leadership and commitment. Without these, the efforts of others in the organization are almost doomed to failure" (p. 177).

Across various high-risk industrial contexts, extensive research has shown the important impact of leadership on safety culture (Yang et al., 2009; Ross, 2011), on safety climate, subordinates' safety compliance and participation behaviours (Clarke, 2013; Pilbeam et al., 2016; Kim and Gausdal, 2020) as well as safety outcomes (e.g., accidents and injury rate) (Mullen and Kelloway, 2009). It has been considered as an important differentiating factor between high and low accident companies (Kjellen, 1982; Bentley and Haslam, 2001; Mattson et al., 2019) and an even more important predictor for safety performance compare to hazard reduction systems (de Koster et al., 2011).

By acknowledging the importance of leadership issues for safety in ship operations, the International Maritime Organization (IMO) has raised the minimum standards of competence for seafarers by including leadership training as a mandatory competence requirement for shipboard officers at both management and operational level (IMO, 2017; Wahl and Kongsvik, 2018; Kim and Mallam, 2020), as specified under the International Convention on Standards of Training, Certification and Watchkeeping (STCW 1978 as amended) (IMO, 2017). However, research into maritime safety leadership (e.g., its determinants, behaviours and process) is very scarce, and it also lacks empirically tested theoretical models – with a validated and reliable scale – for describing and assessing safety leadership in ship operations (Kim and Gausdal, 2017; Besikçi, 2019). This knowledge gap has consequently undermined

* Corresponding author.
E-mail address: tk@usn.no (T.-e. Kim).

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our theoretical understanding and training practice of safety leadership in the maritime context. Current leadership training objectives and materials were largely based on generic leadership knowledge and the Crew Recourse Management (CRM) training adapted from the aviation industry with little sector-specific adjustments and scientific adaptation to the maritime context (Barnett et al., 2003; Oltedal and Lützhöft, 2018). The unique nature of shipping, such as the remote working condition, closed social milieu, exposure to hazardous substances, dynamic situation at sea, as well as the transient and multinational crew composition, has made the ship operational context differ from any other industries (Håvold, 2005; Slišković and Penezić, 2015; Besikçi, 2019). These inherent sector specific characteristics render the effectiveness of transferring leadership knowledge from other industries to the maritime setting (O'Connor, 2011; Oltedal and Lützhöft, 2018; Besikçi, 2019).

In this light, the purpose of this research is to give particular focus to maritime safety leadership, and to design a Safety Leadership Self-Efficacy Scale (SLSES) for describing and assessing shipboard officer's safety leadership self-efficacy in the context of merchant shipping. The research drew upon the insights of safety leadership literature and Bandura's self-efficacy theory, while engaged in a three-stage process to systematically explore and examine the validity and reliability of the measurement scale.

2. Theoretical background

2.1. Safety leadership

Safety leadership has been defined as a process of interaction between leaders and followers to achieve organizational safety goals (Wu, 2005). Leaders' behaviours and the way they interact with their subordinates have been consistently recognized that have significant effect on safety performance (Clarke, 2013) and are important predictors of safety records in many hazardous industrial contexts (Hofmann and Morgeson, 1999; Zohar, 2002). Majority of safety leadership studies have predominantly concerned with investigating and identifying the form of leadership style for safety in formal roles, with reference to a well-established leadership theory (e.g., transformational and transactional leadership theory (Bass, 1985), Leader-Member Exchange (LMX) theory (Graen and Uhl-Bien, 1995), authentic leadership theory (Cooper et al., 2005), situational leadership theory (Graeff, 1983)). Each of these theories view the complex and continuing leadership phenomenon from different angles and emphasize different means for influencing followers. Among which transformational and transactional leadership theory have received the most attention (Clarke, 2013).

Transformational leadership is relationship-oriented, whereas transactional leadership has a stronger task-orientation (Bass and Avolio, 1997). Research based on transformational leadership views leadership as leaders' ability to exert influence to their followers through inspiration, engagement and empathy to achieve "performance beyond expectations" (Zohar, 2003). Transactional leaders focus on maintaining routines, minimizing variations, increasing reliability and predictability from their followers to ensure "expected performance" are in place (Zohar, 2003). A series of studies have shown that a combined use of both transformational and transactional leadership are most beneficial for safety (Clarke, 2013; Kim and Gausdal, 2020). These leadership research are in line with safety theories arguing that to effectively manage safety of today's complex socio-technical systems, it is important to not only avoid that things would go wrong to achieve performance reliability, but also need to increase the system capability to adapt to and succeed under varying conditions and unexpected disruptions to deliver sustainable safety performance (Hollnagel, 2014).

Among limited empirical studies which focused specifically on the study of safety leadership in the shipping industry, an attempt were made by Kim and Gausdal (2017) to synthesize the behaviours and actions manifested by effective leaders in shipping organizations. The study argued that achieving, maintaining and sustaining safety performance in ship operations demands effective safety leadership to be instilled at all organizational levels. Kim and Gausdal (2017) identified eleven key behaviours enabling good safety performance in ship operations, which includes lower-level managers' communicating, caring and supporting, participative involvement; middle-level managers' empowering, monitoring, informing and coordinating; and top managers' enabling, safety concern, inspiring and facilitating behaviours. Organizational leadership for safety significantly influence the learning outcomes from the minor, moderate and major near-misses, which are valuable inputs for the organization to update the safety management practices and generate corrective/preventive actions (Ginsburg et al., 2010). A positive association between the participant's perception of their manager's leadership skills and frequency of incident reporting is also noted by Oltedal and McArthur (2011) in merchant shipping.

Existing literature investigating leadership impact on safety outcomes have provided several important implications: Firstly, it indicated that the variations in individuals and teams' safety practices are causally related to managerial leadership styles and behaviours, and susceptible to influence. Secondly, leaders should excel both task and relationship-oriented leadership in order to effectively influence safety behaviours and outcomes. Thirdly and most importantly, it highlighted the tremendous need for safety leadership assessment and development in order to recognize the current level of performance and identify room for improvement.

2.2. Leadership self-efficacy

Self-efficacy is a critical construct within Bandura's social cognitive theory (Bandura and Walters, 1977), he defined it as: "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performance" (Bandura, 1986, p. 391). It influences on "what challenges to undertake, how much effort to expend in the endeavour, and how long to persevere in the face of difficulties" (Bandura, 1986, p. 29).

Wood and Bandura (1989) has first linked self-efficacy construct to management. Leadership self-efficacy is a key variable regulating leader's functioning in a dynamic environment (McCormick, 2001). It determines not only initiation, intensity and persistence of leadership behaviours (Paglis, 2010), but also fosters the level of motivation, organizational commitment and efficient analytic thinking ability (Wood and Bandura, 1989), with meta-analysis reported a significant correlation G($r_+ = 0.38$) between self-efficacy and performance (Stajkovic and Luthans, 1998). Credible evidence supports the statement that possessing strong leadership self-efficacy could impact not only on leadership effectiveness (Anderson et al., 2008; Hannah et al., 2008) but also the work-related performance (Stajkovic and Luthans, 1998; McCormick, 2001). Anderson et al. (2008) identified 18 dimensions as key components of leadership self-efficacy i.e., change, drive, solve, build, act, involve, self-control, relate, oversee, project credibility, challenge, guide, communicate, mentor, motivate, serve, convince, and know. Leaders with higher self-efficacy are more likely to initiate and engage in leadership attempts (Paglis and Green, 2002), use leadership skills and have better effectiveness compare to those with lower self-efficacy (Anderson et al., 2008). Research also observed that frontline leaders' self-efficacy have direct and positive effects on safety behaviours (Chen and Chen, 2014). Furthermore, self-efficacy, work engagement and human error are significantly correlated, in which self-efficacy significantly predicts probability of human errors in aviation (Li et al., 2018).

In this study, we define *safety leadership self-efficacy* as the extent to which leaders perceive their capabilities to exemplify and execute courses of action required to attain a good safety performance on-board ship. It refers to, for instance, the extent to which shipboard officers perceive their self-efficacy in relation to the development, implementation, and oversight of standard operating procedures (STCW code

Table A-II/2, KUP 6), how they perceive their knowledge and ability to apply decision-making techniques (STCW code Table A-II/2, KUP 5), how they facilitate effective communication (STCW code Table A-II/2, KUP 4), etc (IMO, 2017; Kim and Mallam, 2020). We reason that leadership self-efficacy is particularly important in this safety-critical working environment, where a greater level of confidence and self-belief is needed in order to manage and lead a high-risk activity that has massive risk and uncertainty built-in. Wherein proficient technical competence, a greater level of decisiveness, assertiveness and adaptive skills need to be orchestrated in order to lead effectively, make critical decisions and achieve good performance under the dynamic situations. Thus, measuring leadership self-efficacy is of importance to indicate the current level and recognize room for improvement.

3. Methodology

To reliably and accurately assess a theoretical construct, the measurement tool should be developed following a systematic and rigorous process of development and validation (DeVellis, 2016; Farooq, 2016). The scale development process, as discussed by Carpenter (2018), is both theoretically and methodologically demanding. In this study, the scale development process was divided into three stages, including a content validity study with Subject Matter Experts (SMEs) who are familiar with this topic, an Exploratory Factor Analysis and a Confirmatory Factor Analysis using Structural Equation Modelling, with the goal to examine the content validity through SMEs, and to explore and confirm the underlying factor structure of the scale with shipboard officers. The overall flow of the research is illustrated in Fig. 1, which consists of several key steps taken in this research on the development and estimation of the measurement properties of the safety leadership self-efficacy scale.

3.1. Item generation

One cannot adequately measure self-efficacy without taking into account the specific domain and the actual tasks and responsibilities (Bandura, 2006). The initial item pool was developed by the authors based on the findings from safety-specific leadership research, general leadership self-efficacy research, STCW leadership requirement as well as the inputs of three maritime researchers to adapt general items to maritime context.

Firstly, as described in the theory Section 2.1, several studies have investigated or summarized what constitute effective leadership and highlighted the behaviours or styles that associated with improved safety culture, safety compliance and participation behaviours and other safety-related outcomes in maritime context. In addition to this, we have also considered the general Leadership Self-Efficacy (LSE) taxonomy developed by Anderson et al. (2008), which included 18 dimensions as key components of leadership self-efficacy. These dimensions also have causal relationships with leadership effectiveness, which can be used as a reasonable inventory for understanding different leadership self-efficacy dimensions. Thus, by taking into account these two groups of research, STCW leadership requirements, as well as the knowledge and maritime experience of the investigators, initial 65 items were generated for measuring safety leadership (see Section 4, Table 3). These items are linked not only with leader's personal accountability such as safety commitment, knowledge, confidence and consciousness, but also his/her behaviours and actions that promote safety. Each of these items can be considered as an important behaviour that leaders should exhibit at the frontline level of ship operations, and it is also associated with one dimension of LSE taxonomy (Anderson et al., 2008). For the dimensions that was included in LSE taxonomy, but the causal relationship to safety was not specifically studied in the field of safety leadership research (e.g., self-control), we have still included them in the item pool. An expert panel will be established to review, judge and determine the extent to

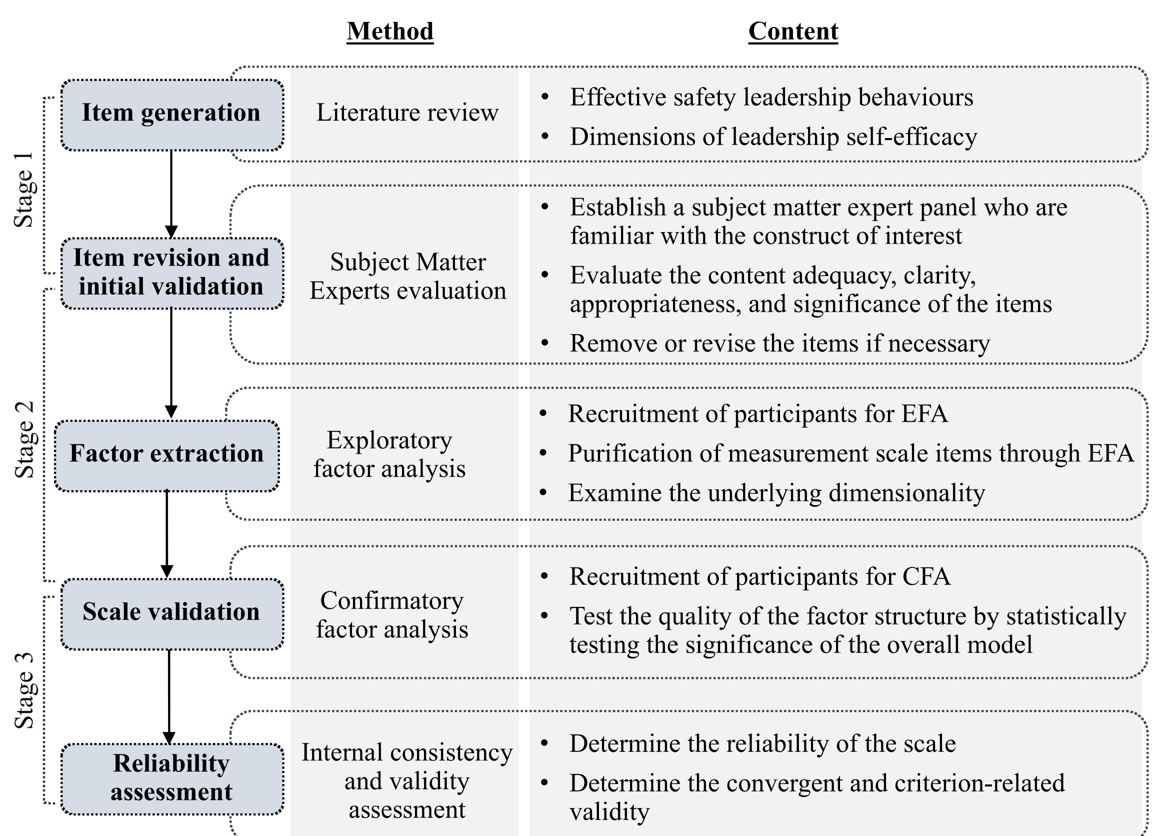

Fig. 1. Safety Leadership Self-Efficacy Scale (SLSES) development process.

which the item could be considered as an important variable to measure.

3.2. Overall scale development process

Stage 1: Content validity assessment process

The first stage has fundamental importance to the instrument development process, as it enables the researchers to validate the representativeness, content validity and clarity of the items through synthesizing the evaluations from subject matter experts. The established item pool was reviewed and evaluated by a team of experts ($N = 20$) to examine the content validity, clarity, appropriateness of each item for measuring safety leadership self-efficacy of shipboard officers. These experts are invited to review the items and rate their viewpoints on the appropriateness of each item on a 9-point Likert scale questionnaire. The experts were also asked to offer their suggestions for adding new items. Demographic profiles of the expert participated in item validation is summarized in the following Table 1.

Total 20 SMEs participated, among which 40% of them work within merchant shipping industry, 60% are university professors, lecturers, researchers in maritime subjects, constituting a strong expert panel to provide reasonable judgement of the items. Based on the SMEs' evaluation, content validity is examined to reflect the degree to which this measurement scale and its items are appropriate for the construct being measured. Content Validity Index (CVI) is the most widely reported approach in scale development studies (Shi et al., 2012; Zamanzadeh et al., 2015). It includes obtaining the validity index for both individual item (I-CVI) and the scale itself (S-CVI). I-CVI can be computed by taking the number of experts who gave a high rating on each item and divided by total number of experts (Zamanzadeh et al., 2015). In addition to CVI, statisticians (e.g., Wynd et al., 2003) have recommended to include a consensus index – Cohen's coefficient kappa (K) – in content validity studies to supplement the CVI, as the CVI does not consider the possibility of inflated values due to chance agreement. Kappa statistics was calculated using the equations below:

$$P_C = [N!/A!(N\text{-}A)!]^* .5^N$$

In which P_c refers to the chance agreement, and A refers to the number of panellists indicating a specific item can appropriately measure the safety leadership self-efficacy of shipboard leaders. N denotes the total number of experts who participated in the panel. After obtaining the results of CVI, Kappa (K) was calculated with the following equation:

$$K = (\text{I-CVI} - P_C)/(1 - P_C)$$

The K value above 0.74 is considered excellent, between 0.60 and 0.74 is good, between 0.40 and 0.59 is fair, below 0.40 is poor (Cicchetti and Sparrow, 1981). The probability of chance agreement will reduce with increasing number of experts and the value of I-CVI and kappa should converge (Zamanzadeh et al., 2015).

Table 1
Demographic characteristics of Subject Matter Experts (SME).

Criteria of classification	Statistics
Sectors	Merchant shipping: 40%
	Maritime research and education: 60%
Years of Experience in shipping	≥ 20: 15%
	16–20: 25%
	10–15: 10%
	6–10: 35%
	≤5: 15%
Experienced maritime accidents	Yes: 75%
	No: 25%
Level of education	High school or equivalent: 15%
	Bachelor's degree: 20%
	Master's degree (including MBA): 35%
	PhD: 30%
Total No. of experts participated	20

Stage 2: Exploratory Factor Analysis (EFA)

Evaluating the performance of the items through factor analysis to assess whether they adequately constitute the scale are considered to be one of the most critical steps in determining the viability of the developed scale. Both EFA and CFA were used in this study to examine the underlying dimensionality of the items, and to test the quality of the factor structure by statistically testing the significance of the overall model.

In stage 2, EFA is performed to determine the number of latent variables based on commonalities within the data and to examine the loading of individual items. Several methods exist for factor extraction in the EFA process, in this study we used Maximum likelihood for extraction as it offers more reliable estimation for scale development research (Worthington and Whittaker, 2006a, 2006b). Oblique rotation (i.e., Promax) method was selected instead of commonly used orthogonal rotation, as it is unreasonable to assume the items to be completely uncorrelated to each other (Fabrigar et al., 1999). Sampling adequacy for EFA was assessed using Kaiser-Meyer-Olkin (KMO) Test, with the criteria to be greater than 0.70 and p-value to be less than 0.01. To ensure rigor of this process, items with factor loading lower than 0.5 and high cross loading (>0.4) (Hatcher, 1994) will be removed at this stage. The Cronbach's alpha of the extracted factors should be >0.70 (Nunnally, 1994).

Stage 3: Confirmatory Factor Analysis (CFA)

After the EFA, we used Structural Equation Modelling (SEM) to examine the relationship between the factors and measured variables, and to test and confirm the factor structure by using a new data set. SEM is a term for a large set of techniques based on the general linear model (Ullman, 2006), in which CFA technique is one type of SEM (Ullman, 2006). The factor structure derived from stage 2 was then incorporated as the measurement model in CFA. This process plays an important role in validating the hypothesized model and finding the reliability of the measurement. Subject samples for factor analyses have included ship masters and officers etc. working on the global merchant shipping industry. The demographical distribution was summarized in Table 2.

In total the data used in stage 2 and 3 was collected from 396 participants from global merchant shipping industry. The diversity of the participants has also been heightened as the questionnaire was distributed in both Europe and Asia to allow for better generalizability. Majority of participants were from the main shipping sectors i.e., tankers, roll-on/roll-off vessels or bulker carriers, who hold leadership positions such as ship captains, chief engineers, deck and engineering department officers. The questionnaires were developed and administered using Qualtrics™ with anonynous link, in which the participants were asked to put their answers on a 9-point Likert-type scale under each

Table 2
Demographic profiles of 396 participants.

Criteria of classification	Range	*N*	Percent (%)
Year of experience as a shipboard leader	More than 20 years	56	14.1
	10–20 years	81	20.4
	Less than 10 years	259	65.4
Leadership positions	Ship masters	64	16.2
	Deck department officers	130	32.9
	Chief Engineer	27	6.8
	Engine department officers	84	21.2
	Bosun and other position	91	23
Shipping sectors	Passenger ships	33	8.3
	Tankers	117	29.5
	Container ships	20	5.1
	RoRo (Roll on Roll Off)	83	21.0
	Seismic vessels	11	2.8
	Fishing Vessels	13	3.3
	Oil industry vessels	39	9.8
	Other ship types (e.g., bulk carriers)	80	20.2

item. The questionnaires were designed with "forced responses" function, questions need to be answered before proceeding further, therefore no missing values was recorded in the dataset. Data analysis were performed using Excel, SPSS v25 and RStudio. Following Kline (2015) and Crawford and Kelder (2019)'s suggestions regarding the reporting of fit indices, we reported the χ2, RMSEA, Bentler's comparative fit index (CFI), Tucker–Lewis's goodness-of-fit index (TLI), and the Standardized Root Mean Square Residual (SRMR) to indicate the model-data fit. Cronbach's alpha, AVE, Construct Reliability (C.R.) were also be assessed. The overall research methodology aligns with both Carpenter (2018) and DeVellis (2016)' guidelines on scale development and reporting.

4. Results

4.1. Results of Stage 1: Content adequacy assessment with subject matter experts

Based on the rationale and criteria described in Section 3, the following Table 3 summarizes the results of S-CVI, I-CVI and kappa (*K*) – the measures that quantify the consensus level of expert opinions on each of the 65 safety leadership self-efficacy measurement items. As shown in the table, the value of the Kappa statistics (K) of all items has all reached above 0.74, which indicates good agreement among SMEs. The CVI of the overall scale has also produced a result of S-CVI/Ave = 0.96, which reflected that the individual items as well as the scale in total has a high level of content validity.

The items contained in the scale have fulfilled the criteria and appeared to be reasonably measure safety leadership self-efficacy of shipboard officers as perceived by the 20 SMEs. Although item 36, 43, 61 have a slightly lower rating compare to the rest (I-CVI = 0.79), they are still within the criteria for inclusion. Accordingly, it can be said that each item is suitable for the given purpose, all items have been kept for next stage of analysis.

4.2. Results of Stage 2: Scale purification

In stage 2, an iterative approach was taken to conduct EFA with the first available 150 samples to purify the measurement items and to explore the latent constructs that cause covariance among items. Factorability of the items was firstly examined, the KMO has yielded an overall measure of sampling adequacy of 0.962, Bartlett's test of sphericity was also significant ($\chi2$ (325) = 4175.945, p < .000), which indicates the existence of a strong relationship between the variables.

The initial result of the analysis was a pattern matrix initially consisting of 7 factors with eigenvalues >1 that account for 76.917% of the variance. Thirty-nine items were dropped during the EFA process due to insignificant loading (<0.5) or high cross-loading (≥0.4). The iterative analysis process has yielded extraction of three factors with 26 items to be considered for inclusion in a hypothesized factor structure for the safety leadership self-efficacy scale, which accounts for 74.821% of the variance but enhances the overview of the matrix considerably. As shown in Table 4, 26 items comprising three factors with loadings vary between 0.523 and 0.859. Each item had a unique contribution to one of these three factors.

Results of the analysis have revealed that safety leadership self-efficacy is a multidimensional construct, which consists of three dimensions (factors) reflecting leader's confidence in their ability to enact safety leadership activities as of now. The items clustered on factor 1 were given the label as leaders' efficacy in *safety motivation facilitation*, it refers to the extent to which shipboard leaders could simulate follower's safety motivation. The items in general related to how leaders use social skills to influence, motivate, and build relationships with crew members to succeed with regards to safety. Items that loaded on the second factor were associated with shipboard leaders' competence for safety management, which includes identifying, managing, controlling and

Table 3
Results of I-CVI, S-CVI and kappa for all items.

Notation	Item description	Importance		I-CVI	*Pc*	*K*
		Rating 3,4,5	Rating 1 or 2			
I1	Have the ability to foresee risks	18	2	0,9474	0,0002	0,95
I2	Able to make changes in personnel and task assignments to ensure safe and efficient operations	18	2	0,9474	0,0002	0,95
I3	Have the ability to change the operation to improve safety	20	0	1,0526	0,0000	1,05
I4	Have the ability to establish new rules and work procedures to improve safety	19	1	1,0000	0,0000	1,00
I5	Capable of gathering safety information to make necessary changes	19	1	1,0000	0,0000	1,00
I6	Encourage learning as a basis for improving safety	19	1	1,0000	0,0000	1,00
I7	Able to identify hazards proactively	19	1	1,0000	0,0000	1,00
I8	Able to proactively manage safety risks	19	1	1,0000	0,0000	1,00
I9	Able to use formal authority to ensure crew members adhere to the safety procedures and policies	19	1	1,0000	0,0000	1,00
I10	Ensure achievable safety goals are set	19	1	1,0000	0,0000	1,00
I11	Prioritize safety over other business targets and activities	19	1	1,0000	0,0000	1,00
I12	Follow up crew members to ensure that tasks are completed in a timely and efficient manner	16	4	0,8421	0,0046	0,84
I13	Make concrete plans and programs for the safety activities	18	2	0,9474	0,0002	0,95
I14	Have sufficient knowledge of the technical performance of the vessel	20	0	1,0526	0,0000	1,05
I15	Provide expert knowledge to crew members	18	2	0,9474	0,0002	0,95
I16	Have the capacity to manage the technical skills of the crew members	19	1	1,0000	0,0000	1,00
I17	When undesirable incidents occur, be able to follow the established	20	0	1,0526	0,0000	1,05

(*continued on next page*)

Table 3 (*continued*)

Notation	Item description	Importance		I-CVI	*Pc*	*K*
		Rating 3,4,5	Rating 1 or 2			
	procedures to deal with the situation					
I18	When undesirable incidents occur, be able to improvise to handle the situation effectively	18	2	0,9474	0,0002	0,95
I19	Able to develop effective teams to operate safely	20	0	1,0526	0,0000	1,05
I20	Allocate resources adequately to ensure safe and efficient operation	20	0	1,0526	0,0000	1,05
I21	Able to ensure necessary safety precautions are being carried out by conducting regular supervision	17	3	0,8947	0,0011	0,89
I22	Participate actively in workforce safety activities and initiatives	18	2	0,9474	0,0002	0,95
I23	Able to make sound decisions and the right choices	19	1	1,0000	0,0000	1,00
I24	Able to mobilize the resources to make effective decisions in a timely manner	18	2	0,9474	0,0002	0,95
I25	Confident that crew members will follow up leaders' decisions	18	2	0,9474	0,0002	0,95
I26	Able to initiate and engage in toolbox sessions during safety meetings on board	18	2	0,9474	0,0002	0,95
I27	Involve crew members actively in recommending revisions to established procedures	19	1	1,0000	0,0000	1,00
I28	Able to delegate work tasks effectively and encourage crew members to accept responsibility for safety	18	2	0,9474	0,0002	0,95
I29	Actively listen to the crew members, and promote their involvement in decision making	19	1	1,0000	0,0000	1,00
I30	Seriously consider the subordinates' suggestions and initiatives for improving safety	19	1	1,0000	0,0000	1,00
I31	Able to successfully foster effective collaboration among crew members	18	2	0,9474	0,0002	0,95
I32	Able to foster positive attitudes and mutual respect among crew members	18	2	0,9474	0,0002	0,95
I33	Monitor performance and ensure that safety procedures are followed by crew members	18	2	0,9474	0,0002	0,95
I34	Use appropriate sanctions to respond to unsafe actions	16	4	0,8421	0,0046	0,84
I35	Able to closely observe crew performance during safety drills on board, and highlight shortcomings and good work	18	2	0,9474	0,0002	0,95
I36	Encourage crew members to create peer pressures to avoid safety complacency	15	5	0,7895	0,0148	0,79
I37	Treat all crew members with dignity and respect	20	0	1,0526	0,0000	1,05
I38	Willing to deal with resistance from crew members in an open and constructive manner	20	0	1,0526	0,0000	1,05
I39	Concerned with how crew members perceive justice and seek to lead in a fair manner	18	2	0,9474	0,0002	0,95
I40	Appear honest and credible to others	19	1	1,0000	0,0000	1,00
I41	Challenge their own and the team's performance against safety objectives to avoid complacency	16	4	0,8421	0,0046	0,84
I42	Set high safety standards for vessel operations	18	2	0,9474	0,0002	0,95
I43	Pioneer in achieving high safety standards	15	5	0,7895	0,0148	0,79
I44	Use logical arguments and factual evidence to ensure crew members' compliance with safety rules/ procedures	17	3	0,8947	0,0011	0,89
I45	Use good seamanship in	19	1	1,0000	0,0000	1,00

(*continued on next page*)

Table 3 (*continued*)

Notation	Item description	Importance		I-CVI	*Pc*	*K*
		Rating 3,4,5	Rating 1 or 2			
	leading and training the crew					
I46	Have the necessary competence to provide proper directions to the crew	20	0	1,0526	0,0000	1,05
I47	Provide feedback on task performance frequently	16	4	0,8421	0,0046	0,84
I48	Foster open and frequent communication among crew members on safety issues	19	1	1,0000	0,0000	1,00
I49	Able to clearly articulate the desired safety behaviours and work practices	18	2	0,9474	0,0002	0,95
I50	Have the cultural awareness to communicate effectively with all crew members	19	1	1,0000	0,0000	1,00
I51	Circulate important safety information among crew members	19	1	1,0000	0,0000	1,00
I52	Able to lead by example, and communicate the importance of safety through both words and actions	20	0	1,0526	0,0000	1,05
I53	Care about crew member' safety, express compassion and empathy where appropriate	20	0	1,0526	0,0000	1,05
I54	Provide recognition and incentives to crew members for promoting positive safety on board ship	18	2	0,9474	0,0002	0,95
I55	Provide positive emotional support and take care of the crew's welfare	17	3	0,8947	0,0011	0,89
I56	Make the crew more confident to accomplish their tasks	17	3	0,8947	0,0011	0,89
I57	Encourage people to report errors, near-misses or other safety-related information without fear of the consequences	20	0	1,0526	0,0000	1,05
I58	Confident in ensuring the motivation of crews to follow	18	2	0,9474	0,0002	0,95

Table 3 (*continued*)

Notation	Item description	Importance		I-CVI	*Pc*	*K*
		Rating 3,4,5	Rating 1 or 2			
	Safety Management Systems (SMS)					
I59	Will not bend safety rules to achieve performance targets	18	2	0,9474	0,0002	0,95
I60	Willing to reflect on, and revise leader's decisions based on feedback from the crew	18	2	0,9474	0,0002	0,95
I61	Explain and justify the activities to be performed to give more purpose to the task	15	5	0,7895	0,0148	0,79
I62	Able to galvanize the crews' support to achieve safety standards and goals	17	3	0,8947	0,0011	0,89
I63	Aware of their influence and know what leadership strategies or tactics are needed to ensure safety in various situations	17	3	0,8947	0,0011	0,89
I64	Capable of sourcing the pertinent information for decision making	18	2	0,9474	0,0002	0,95
I65	Capable of keeping safety information updated	19	1	1,0000	0,0000	1,00

Note: I-CVI refers to content validity index for each item, Pc is the probability of a chance occurrence. Kappa statistics (K): <. 40 is poor, 0.40-0.59 Fair, 0.60-0.74 is Good, 0.75–1.00 is Excellent (Cicchetti and Sparrow, 1981).

handling risk and hazardous situations during ship operations. Accordingly, factor 2 was labelled as *safety management* efficacy. The third group of items included specific, discrete verbal and nonverbal leadership behaviours and initiations that encourage subordinates to be involved in safety activities, which in general reflected leaders' efficacy on taking *safety initiative*.

The EFA process has reduced the 65 items measurement scale to a more manageable number. As shown in Table 5, the factor correlations ranged from 0.730 to 0.763, suggesting a higher order factor that should be tested during next CFA stage.

In this stage, the overall Cronbach's α of the scale with 26 items was 0.979. The three subscales have also obtained excellent internal consistency: Cronbach's α has reached 0.971 for efficacy in safety motivation facilitation, 0.933 for efficacy in safety management and 0.923 for efficacy in taking safety initiatives. The Corrected Item-Total Correlation was ranged from 0.619 to 0.874. The Alpha If Item Deleted also showed that the α value would not be improved if any of the items being eliminated, thus all 26 items derived from EFA were worthy of retention for next scale validation stage.

4.3. Results of Stage 3: Scale validation and reliability assessment

In Stage 3, a CFA analysis was conducted using 396 samples with maximum likelihood robust estimation to validate the model derived

Table 4
Results from Exploratory Factor Analysis ($n = 150$).

Factor label	Items	Loading	Communalities	
			Initial	Extracted
Factor 1: Efficacy in Safety Motivation Cronbach's α = 0.971	I57	0.859	0.779	0.720
	I58	0.834	0.770	0.752
	I56	0.811	0.800	0.756
	I40	0.782	0.703	0.614
	I63	0.742	0.724	0.652
	I49	0.673	0.841	0.816
	I48	0.673	0.865	0.833
	I39	0.671	0.774	0.709
	I53	0.617	0.772	0.737
	I37	0.578	0.757	0.660
	I46	0.560	0.807	0.739
	I44	0.546	0.798	0.726
	I50	0.544	0.766	0.723
	I60	0.534	0.721	0.674
Factor 2: Efficacy in Safety Management Cronbach's α = 0.933	I30	0.729	0.834	0.846
	I29	0.725	0.838	0.808
	I18	0.718	0.722	0.695
	I2	0.675	0.610	0.486
	I24	0.531	0.797	0.743
	I8	0.523	0.748	0.662
Factor 3: Efficacy in Safety Initiative Cronbach's α = 0.923	I26	0.846	0.794	0.798
	I47	0.730	0.719	0.671
	I43	0.653	0.716	0.684
	I27	0.651	0.798	0.769
	I35	0.602	0.774	0.672
	I10	0.587	0.681	0.581

Table 5
Factor correlation matrix.

Factor	1	2	3
1	1.000		
2	0.750	1.000	
3	0.763	0.730	1.000

through Stage 2 (EFA). Two items (I37 and I43) were dropped due to low r-square value during the initial CFA. The final model, as illustrated in the following Fig. 2, was tested and it revealed that the model fits the data well, the goodness-of-fit indices are adequate with $\chi^2 MLR$ (249, N = 396) = 493.904 ($p < .001$), R-CFI = 0.947, R-TLI = 0.941, CFI = 0.944, TLI = 0.938, RMSEA = 0.050 (90% CI, [0.045,0.055]), Standardized RMR = 0.034.

The result confirms a second-order model in which safety leadership self-efficacy (second-order factor) is comprised of three first-order factors including efficacy in safety management, efficacy in safety motivation facilitation and efficacy in taking safety initiatives. The final CFA estimation is presented in the following Table 6.

All standardized coefficient beta (β) are above 0.7, R-squared are above 0.5 indicating superb explanatory power. The standard structural coefficients of the first order factor on safety leadership self-efficacy construct are the estimates of the validity of the factors, thus the larger the factor loadings are, the stronger the evidence that the factors represent the underlying construct. The loadings are high (i.e., 0.946, 0.961 and 0.963), which indicates that the safety leadership self-efficacy can be well explained by these three first-order factors and reflected the contribution of safety leadership efficacy on its three sub-constructs is good. Parameter estimates for the confirmatory factor model are significant at the 0.001 level. The overall internal reliability of SLSES is 0.971. Cronbach's α of the subscales and Composite Reliability (C.R.) were calculated as shown in Table 7.

As shown in Table 6 and 7, the factor loadings of the observed variables (standardized λ) are significant between 0.707 and 0.861, which indicates good convergent validity. Cronbach's alpha of the subscales were ranged from 0.887 to 0.954, AVEs are above 0.6, and the composite reliabilities of each dimension have also exceeded the recommended upper level of 0.70, indicating reasonable reliability of the model. Content validity index of the scale was recalculated based on the result of stage 3, S-CVI/Ave is 0.914, indicating excellent content validity of the scale. Based on the three stages presented above, the final Safety Leadership Self-Efficacy Scale (SLSES) was constructed. All factors and their items remained in the final scale appeared to have good conceptual consistency, adequately explained safety leadership of shipboard officers, and successfully covered what we have tried to identify as the core functions of a safety leader.

5. Discussion

This study presented the development and validation process of a Safety Leadership Self-Efficacy Scale (SLSES) to prepare an instrument to aid in understanding and predicting safety leadership of shipboard officers. The resulting scale has demonstrated adequate measurement properties with good validity and reliability.

SLSES consists of three subscales (factors) to reflect leader's efficacy in their ability to facilitate motivations, manage safety and take safety initiatives. The first factor, efficacy in motivation facilitation, reflected an important leadership function which is to inspire motivation of their

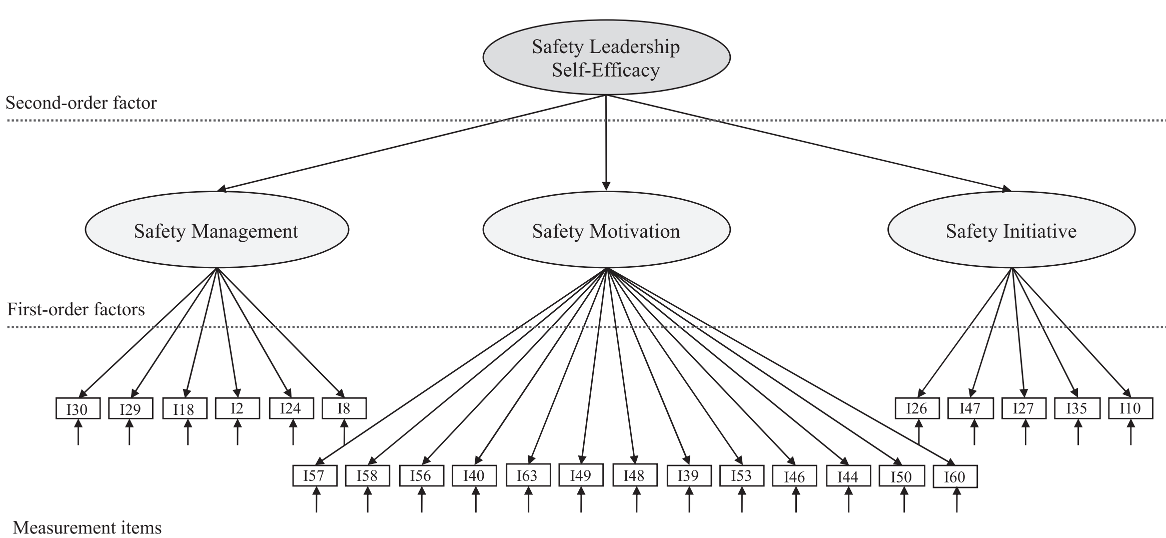

Fig. 2. Measurement model.

Table 6
Final result from Confirmatory Factor Analysis ($n = 396$).

Notation	Item	Estimate		R^2	S.E.	z-value	P(>|z|)	Cronbach Alpha
		B	β					
Efficacy in safety motivation facilitation			*0.946					0.954
I57	Encourage people to report errors, near-misses or other safety-related information without fear of the consequences	1.000	0.767	0.588			1.116	
I58	Confident in ensuring the motivation of crews to follow Safety Management Systems (SMS)	1.096	0.794	0.631	0.065	16.925	0.000	
I56	Make the crew more confident to accomplish their tasks	1.020	0.804	0.646	0.053	19.186	0.000	
I40	Appear honest and credible to others	0.978	0.739	0.546	0.053	18.547	0.000	
I63	Aware of their influence and know what leadership strategies or tactics are needed to ensure safety in various situations	0.994	0.799	0.639	0.074	13.384	0.000	
I49	Able to clearly articulate the desired safety behaviours and work practices	1.085	0.849	0.721	0.069	15.628	0.000	
I48	Foster open and frequent communication among crew members on safety issues	1.083	0.826	0.683	0.069	15.650	0.000	
I39	Concerned with how crew members perceive justice and seek to lead in a fair manner	0.988	0.762	0.580	0.062	15.860	0.000	
I53	Care about crew member' safety, express compassion and empathy where appropriate	0.952	0.771	0.594	0.056	17.033	0.000	
I46	Have the necessary competence to provide proper directions to the crew	1.154	0.807	0.651	0.076	15.095	0.000	
I44	Use logical arguments and factual evidence to ensure crew members' compliance with safety rules/procedures	0.990	0.804	0.646	0.056	17.597	0.000	
I50	Have the cultural awareness to communicate effectively with all crew members	1.063	0.722	0.521	0.083	12.761	0.000	
I60	Willing to reflect on, and revise leader's decisions based on feedback from the crew	0.916	0.760	0.578	0.074	12.457	0.000	
Efficacy in safety management			*0.961					0.906
I30	Seriously consider the subordinates' suggestions and initiatives for improving safety	1.000	0.806	0.650			1.076	
I29	Actively listen to the crew members, and promote their involvement in decision making	1.078	0.814	0.662	0.074	14.596	0.000	
I18	When undesirable incidents occur, be able to improvise to handle the situation effectively	1.092	0.791	0.625	0.093	11.704	0.000	
I2	Able to use formal authority to ensure crew members adhere to the safety procedures and policies	1.047	0.707	0.500	0.096	10.918	0.000	
I24	Able to mobilize the resources to make effective decisions in a timely manner	1.098	0.861	0.741	0.083	13.213	0.000	
I8	Able to proactively manage safety risks	0.977	0.745	0.555	0.069	14.096	0.000	
Efficacy in safety initiative			*0.963					0.887
I26	Able to initiate and engage in toolbox sessions during safety meetings on board	1.000	0.801	0.641			1.279	
I47	Provide feedback on task performance frequently	0.953	0.769	0.591	0.063	15.040	0.000	
I27	Involve crew members actively in recommending revisions to established procedures	0.963	0.807	0.651	0.038	25.197	0.000	
I35	Able to closely observe crew performance during safety drills on board, and highlight shortcomings and good work	0.931	0.814	0.662	0.050	18.646	0.000	
I10	Ensure achievable safety goals are set	0.760	0.723	0.523	0.054	14.156	0.000	
	SLSES TOTAL							**0.971**

Table 7
Cronbach's α, composite reliability and average variance extracted.

Factor	Cronbach's α	Composite Reliability (C.R.)	Average Variance Extracted (AVE)
Efficacy in safety motivation facilitation	0.954	0.954	0.617
Efficacy in safety management	0.906	0.908	0.622
Efficacy in safety initiative	0.887	0.888	0.614

crew members to actively participate, freely report and pay attention to the procedures in order to succeed with regards to safety. The items listed under this subscale incorporated various leadership behaviours that directly or indirectly facilitate crew members motivation for safety, such as encouraging people to report errors, near-misses or other safety-related information without fear of the consequences, using logical arguments and factual evidence to ensure crew members' compliance with safety rules and procedures, etc. The extent to which leaders create a motivation system to encourage their followers' safety behaviours, namely safety motivation, is closely linked to the transformational leadership (Du and Sun, 2012). Transformational leaders inspire confidence, articulate goals, motivate subordinates to take extra efforts and so that it can improve the performance beyond expectation (Zohar, 2002). The items grouped into this factor are largely in line with transformational leadership theory which implies that the exercise of good transformational leadership behaviours would reflect safety leadership potentials to motivate subordinates in engaging in safety efforts.

Items loaded on the second factor were associated with shipboard leaders' competence for safety management, which is another core feature of safety leadership. Items used to assess this factor included several key management practices related to the needed for standardization, reliability, as well as the required improvising skills. Measurement items included the extent to which the shipboard leaders could proactively managing risks, mobilizing resource, implementing measures to ensure safety compliance, improvising to handle dynamic situations during ship operations, etc. These items are mainly associated with the transactional leaders' behaviours that aimed to ensure the expected performance standards are met (Martínez-Córcoles and Stephanou, 2017), though they also include items that reflect on the inclusion of subordinates and improvisation, more characteristic of transformational leadership behaviours (Bass and Avolio, 1997). Lately, there has been some discussions regarding the distinction between the "safety management" and "safety leadership", as these two terms have been used interchangeably in maritime context. Our research finding has shown that safety management is one dimention of safety leadership. Good shipboard leaders need to exercise both formal and informal leadership functions to not only enforce the safety rules to ensure people behave in a safe manner, but also to use good seamanship, influence practices and social skills to increase subordinate's risk awareness, motivation and willingness to act safely.

The third subscale is used to measure shipboard leaders' efficacy in taking safety initiative, which has made the highest contribution to the overall safety leadership self-efficacy ($\lambda = 0.963$). Leaders proficiency in exercising specific, discrete verbal and nonverbal leadership behaviours and initiations to encourage subordinates to be involved in safety activities, reflect leaders' efficacy on taking safety initiatives. They include setting goals, monitoring behaviour, providing feedback, and such. The items under the subscale on safety initiative also predominantly reflects a transactional leadership style (Stogdill and Bass, 1981).

The findings of this study reflect previous research that concludes that a combined approach of transformational and transactional leadership behaviours are most benefitial for safety leadership (Clarke, 2013). The SLSES demonstrates that there is no dichotomy between transactional and transformational leadership styles, but rather that safety leadership incorporates both. Meanwhile, it is also provides the important insight that the transactional and transformational leadership styles vary in importance in terms of leaders abilities to motivate, manage safety and take safety initiatives. This provides direction to future studies of leadership studies in the maritime industry. Finally, the proposed SLSES highlights the need for adaptive safety leadership, to handle complexity and uncertainty while achieving sustainable safety performance (Hollnagel, 2014).

Studies have recognized that effective leadership requires leaders to be skilled in use of influence (Yukl and Falbe, 1990), have good level of motivation and confidence towards their own leadership capabilities (Allen et al., 2014), and have psychological and behavioral resources to deal with the emerging demands during times of change and stress (Fredrickson, 2001; Hannah et al., 2008). SLSES incorporated the items that could help in assessing these aspects. It has also several important benefits for the shipowners, crew management companies and maritime training providers, as it forms a valuable source of information regarding the shipboard officer's leadership potential for safety and can serve as a means or a basis for decisions regarding future training and other personal development efforts. The scale can be used before and after the mandatory STCW leadership training to identify the area of safety leadership they are weakest in to guide the training effort. Subordinates would not want to follow a leader who appears to lack in confidence. Vice versa, when a leader does not exhibit confidence in their own decisions and actions, they do not engender confidence in their subordinates. It is expected SLSES could lead to diverse approach in practice to acknowledge and augment one's safety leadership capacity.

Despite the contribution of the proposed SLSES, future research should be conducted. In this study, by following up on an expert consensus survey, we used 150 samples for EFA, 396 samples for CFA, which is in accordance with the sampling recommendations (Worthington and Whittaker, 2006a, 2006b). Since the communalities for all items in the initial EFA were high, sample size have relatively little impact on the quality of the factor analysis solution, which means that "accurate recovery of population solutions may be obtained using a fairly small sample" (MacCallum et al., 1999, p. 90). However, follow-up studies should use a larger sample size to validate the developed scale, to conduct correlational analysis and to assess the predictability of SLSES for safety culture, near-misses reporting rate, or other indicators of actual safety performance. In addition, there are many sociodemographic factors (e.g., nationality, education, seniority, gender) and shipping sector-specific characteristics could affect leadership styles and safety behaviors. It is worthwhile to expand research in this area to obtain a fuller picture of maritime safety leadership phenomenon.

As organizations evolve in an increasingly complex environment – characterized by new technological, regulatory, social and economic challenges, the dynamic situations occurring at sea and shore, the amount of administration procedures and papers often intensify the pressure and demands placed on the leaders. When evaluating the safety leadership self-efficacy, personal factors as well as the context and situations encountered by the leaders might need to be considered. The evaluation of leaders' self-efficacy for safety should involve an appraisal of the interaction of the perceived capabilities with the situational demands and obstacles.

6. Conclusion

While regulatory bodies make substantial efforts in promulgating safety rules and conventions to enhance safety standards, the effect and consequently the safety performance ultimately depends upon how organizations and their leaders value safety and approach its implementation. Safety leadership is a key driver to a mature safety management system and this study can add to this area. Given that this is the first safety leadership self-efficacy measurement scale in a maritime context, it may provide a distinct contribution to theory-building and practice of leadership training in maritime education and training institutions. SLSES can be used as an instrument to diagnose shipboard leader's self-efficacy level and allows the shipping companies to examine the belief, attitude and behavioural patterns prior to the promotion and selection of leaders. By providing an understanding of the current level of safety leadership self-efficacy, it can help training instructors to determine the best approach to increase trainees' self-efficacy based on the relative scores in each safety leadership dimension.

In conclusion, we expect that the SLSES could lead to diverse approach in maritime research and training practice to augment individual safety leadership capacities and to create a high safety leadership efficacy climate.

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