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Assessing the Relationships Between Organizational Management Factors (4Ps) and a Resilient Safety Culture in a Collegiate Aviation Program with a Safety Management Systems (SMS)

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ASSESSING THE RELATIONSHIPS BETWEEN ORGANIZATIONAL MANAGEMENT FACTORS (4Ps) AND A RESILIENT SAFETY CULTURE IN A COLLEGIATE AVIATION PROGRAM WITH A SAFETY MANAGEMENT SYSTEMS (SMS)

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Resilient safety culture is a key factor in sustaining safety management systems (SMS) in a U.S. collegiate aviation program. The relationships between four organizational management factors (*Principles*, *Policy*, *Procedures*, *Practices*) and a resilient safety culture model based on Reason's concept was assessed using an online survey instrument. Structural Equation Model (SEM) technique were used to assess measurement models of factors underlying a resilient safety culture. All four management factors had significant predictive relationship with resilient safety culture. *Practices* had the weakest predictive relationship with resilient safety culture and *Policy* had the highest. *Procedures* strongly mediated path between *Policies* and *Practices* and there was no significant predictive relationship between *Principles* and *Practices*. Results suggest a good resilient safety culture within the aviation program even though more focus should be placed on *Practices*. Study adds to the paucity of existing literature on resilient safety culture in U.S. collegiate aviation programs.

A resilient safety culture is a characteristic of an organization that has good safety procedures and practices which enable it to have greater resistance to incidents and accidents, as well as being able to cope better when they occur (Hollnagel, Paries, Woods, & Wreathall, 2011). A safety resilient culture is essential for Safety Management Systems (SMS) which is a formal, top-down, organization-wide approach to managing safety risk and assuring the effectiveness of safety risk controls. It includes systematic procedures, practices, and policies for the management of safety risk (ICAO, 2013). Within the scope of an SMS, a resilient safety culture is known to be reflected in proactive and resilient behaviors of personnel in an organization and also serves as indirect indicator of good organizational management factors (Schwarz, Wolfgang, & Gaisbachgrabner, 2016). Resilient safety culture within the aviation environment has been promoted through extant research (Akselsson, Koorneef, Stewart & Ward, 2009; Reason, 2011; Hollnagel, 2014; Schwarz, Wolfgang, & Gaisbachgrabner, 2016) and the findings of these research advocate for robust and resilient safety systems as the next level in an organization with a fully functional SMS program in place. Some collegiate aviation programs in the U.S. have adopted the SMS voluntary program (SMSVP) facilitated by the Federal Aviation Administration (FAA). The SMSVP provides immense benefits in terms of enhanced proactive safety risk management and a resilient safety culture sustained in their operations (Adjekum, 2014; Adjekum, 2017). Under the SMSVP, a certificate holder that satisfies all the rigorous requirements of SMSVP may be recognized by the FAA and designated an *active conformance* status (FAA, 2015). A key performance metric of a functional and mature SMS is a resilient safety culture under all operational conditions (Paries, Macchi, Valot & Deharvenght, 2018). Measuring resilient safety culture is an essential part of SMS and a path towards continuous

monitoring and improvements of organizational safety (Stolzer, Friend, Truong, & Aguiar, 2018). Reason (2011) provides a measurement strategy through a conceptual model of a resilient safety culture engine that drives an organization's safety program based on the Degani and Wiener (1991) model of organizational management factors namely; *Principles*, *Policies*, *Procedures* and *Practices* (4Ps). The aim of this study was to assess hypothesized measurement models showing the strength of relationships between a resilient safety culture and 4Ps management factors in a collegiate aviation program

Research Design & Results

Quantitative survey items modified from Reason's attributes of a proactive safety resilient organization (Reason, 2011) were sent via an anonymous online survey link to all personnel (aviation students, certified flight instructors, faculty, maintenance personnel, dispatch, administrative, and top-management) in a collegiate aviation program located in the mid-Western part of the United States that has an *active conformance* SMS. The collegiate aviation program had a population of 1695 and there were 516 responses (~ 31% response rate) at the end of the survey period which is adequate for most internal online surveys (Tse-Hua & Xitao, 2009). Generally, the response numbers as compared to the non-response suggest minimal response bias. The results show a mean age of about 23 years (M =22.94, SD = 7.944) the modal class being the 20-year old respondents and the highest age being 67 years. There were 396 male respondents (76.7%) as compared to 120 female respondents (23.3%).

Question One

What is the strength of relationships between measurement scale items and their latent management factors (Principles, Policy, Procedures and Practices)?

Principles. According to Reason (2011), *Principles* are a corner stone of policy framework, operational procedures and "sharp-end" practices in aviation organizations. It is determined by an organization's management and becomes a conclusive statement on how operations at the organization is conducted. A resilient safety culture in an organization has an impact on strategic principles, which may not always be clearly stated but will be inferred from procedures, policies and practices (Degani & Wiener, 1991). An item under *Principles* is "Safety is recognized as being everyone's responsibility not just that of the safety management team". A first-order CFA which allows researchers to test hypotheses about a factor structure (Brown, 2006; 2015) was used in assessing the strength of relationship. The goodness-of-fit index for the model was $\chi 2$ (5, N =516) = 6.048, p = .302, CMIN/DF = 1.210 NFI=.988, IFI=.998, TLI=.994, CFI=.998, RMSEA = .020 (.000 -.067).

Policy. Reason (2011) suggest that *Policy* (M= 4.39, SD = .443) guides specifications in which management describe how certain operations are to be performed. Management will have policy guidelines that described training, maintenance, line operations and personal conduct etc. They are developed based on the organization's strategic principles but further determined by commercial and operational factors. Example of an item under *Policy* is "Policies ensure that supervisory personnel are present throughout high-risk procedures". The goodness-of-fit index for the model was $\chi 2$ (12, N =516) = 21.916, p = .038, CMIN/DF = 1.826, NFI=.948, IFI=.976, TLI=.941, CFI=.975, RMSEA = .040 (.009 -.066).

Procedures. Reason (2011) and Degani and Wiener (1981) suggest that *Procedures* (M= 4.68, SD = .034) should be developed that are in line with an organization's principles and policy framework. *Procedures* should specify the nature of a task, time and sequence for conducting task, actions required, sequence of task and required feedback mechanism. The goodness-of-fit index for the model was $\chi 2$ (9, N =516) = 21.473, p = .011, CMIN/DF = 2.386, NFI=.965, IFI=.979, TLI=.951, CFI=.979, RMSEA = .052 (.024 -.080).

Practices. Reason (2011) suggest that *Practices* (M= 3.74, SD = .777) are the actual activities that occur at the 'sharp-end" of any organization and personnel are responsible for ensuring that these are in line with standard operating procedures (SOPs). However, deviations can occur when these actions differ from an organization's procedure. These deviations can be minor or major occurrences and, in some cases, lead to an accident. The goodness-of-fit index for model was $\chi 2$ (8, N =516) = 19.623, p = .012, CMIN/DF = 2.452, NFI=.907, IFI=.943, TLI=.893, CFI=.939, RMSEA = .053 (.023 -.083).

Reliability and construct/discriminant validity. The reliability, convergent validity, and discriminant validity of the four management factors that relates resilient safety culture were assessed. A Cronbach's alpha value of 0.7 or higher indicates good reliability of measured items (Nunnally, 1978). In addition, a composite reliability (CR) of 0.7 or higher suggests good reliability and indicating internal consistency exists (Hair, Ringle, & Sarstedt, 2011). Factor loadings and average variance extracted (AVE) methods were used to assess the convergent validity (Fornell and Larcker, 1981; Hair et al., 2011). The Heterotrait-Monotrait ratio of correlations (HTMT) approach with a predefined criterion/ absolute threshold of 0.90 was used for discriminant validity due to its high sensitivity (Henseler, Ringle, & Sarstedt, 2015). Both Cronbach's alpha and composite reliability values for 4Ps indicated acceptable reliability. All the factors had an AVE $\geq .50$ and above suggesting an acceptable convergent validity for the instrument. The $HTMT_{0.90}$ result suggests evidence of discriminant validity since the inter-construct correlation ratios were less than the criterion of 0.90.

Question Two

What is the strength of relationships between management factors (Policy, Principles, Procedures, and Practices) and the overarching construct resilient safety culture in a collegiate aviation SMS program?

The measured constructs for the four factors were derived by summing the measurement items in each validated CFA model. The new variables were then used to assess the strength of relationships with the over-arching concept of resilient safety culture. The analysis yielded a model with goodness-of-fit index as follows: χ^2 (2, *N*=516) = 5.586; *p* = .061; CMIN/DF = 2.793; NFI = .985; RFI = .925; IFI=.990; TLI =.951; CFI= .990; RMSEA = .029 (.015 - .057). Figure 1 shows the final measurement model of relationship between 4Ps and resilient safety culture.

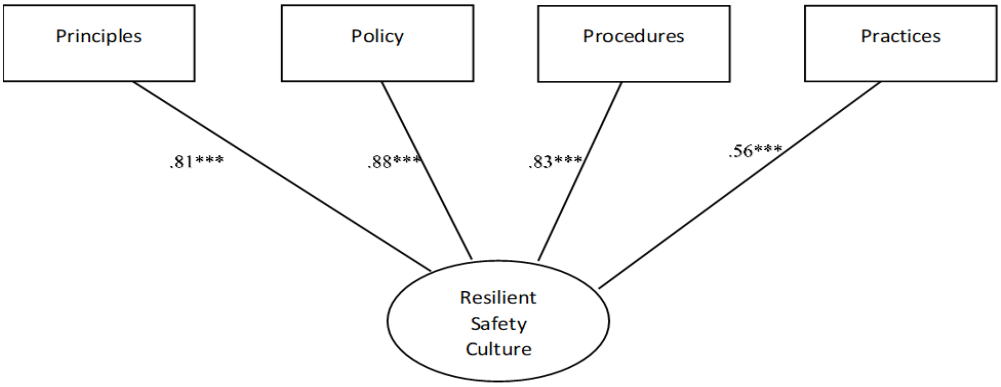

Figure 1. Model showing relationship between 4Ps and resilient safety culture (***$p < .001$)

Question Three

What is the strength of relationships between management factors Policy, Principles, and Practices when mediated by the Procedures in a collegiate aviation SMS program?

The preliminary analysis of a fully mediated 4Ps measurement model failed to produce any acceptable fit. A post-hoc iteration was done on the fully mediated 4P safety resilience model using the modification indices function and a direct path from *Principles* to *Practices* was then removed and a new analysis re-run. The resulting partially mediated model produced a good fit as shown by the fit index: χ^2 (1) = 1.175; p = .278; CMIN/DF = 1.178; NFI = .997; RFI = .968; IFI=.998; TLI =.995; CFI= .998; RMSEA = .019 (.000 -.119). Figure 2 shows the partially-mediated 4Ps measurement model.

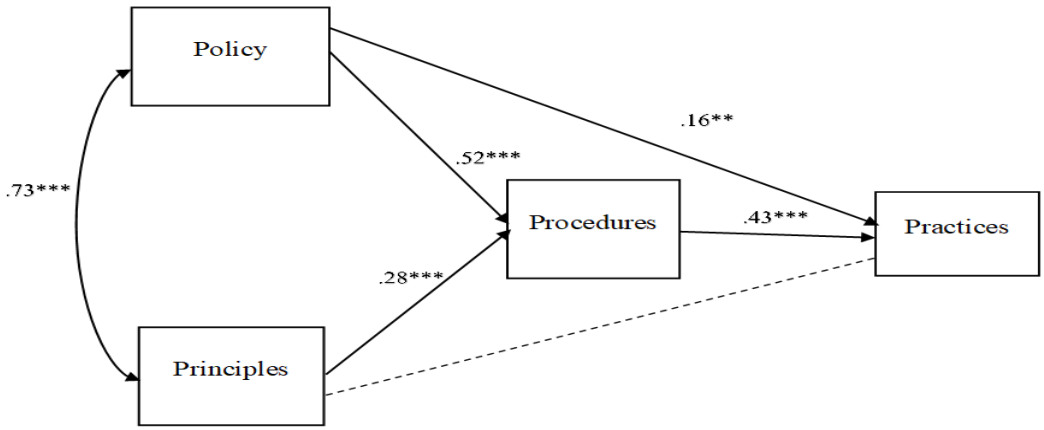

Figure 2. Partially Mediated 4Ps Measurement Model (*** p < .001; **p <. 005)

Discussions and Conclusion

A strategic management implication of this study is that resilient safety culture is strongly influenced by the policies, procedures and principles within an organization and periodic

assessments should be conducted to identify gaps and weaknesses related to these factors that can adversely affect a resilient safety culture. This aligns strongly with the findings of Akselsson et al. (2009) on resilient safety culture in air traffic control environment and Reason's conceptual framework on resilient safety culture (Reason, 2011). This finding is also consistent with the need for robust organizational policies and procedures that are primed by a principle that ensure safe and highly resilient flight operations (Degani and Weiner, 1991). The relatively weak relationship between *Practices* and resilient safety culture as compared to the other organizational factors could be attributed to inadequate awareness of resilient safety practices within the collegiate aviation program by some respondents which potentially can affect their perceptions and responses to items related to that factor. An increased focus on resilient safety practices such as safety empowerment may be expedient as part of the SMS promotion activities. This allows for cognizance of safety risk in operational environments and authority to suspend activities when risk exceed tolerable levels required for a task. There was a high correlation between *Policy* and *Principles* that underscores the important role that over-arching principles have in shaping the policy framework of any organization. The results also support literature that suggest that *Policy* framework forges a consistent and pragmatic review of procedures for use by "sharp-end" employees in an organization. (ICAO, 2013; Stolzer, 2018). The strongest predictive relationship was between *Procedures* and *Practices*. However, *Procedures* strongly mediated the path between *Policies* and *Practices*, which suggest that without comprehensive procedures outlining policies, it may be a challenge to sustain resilient practices among "sharp-end" employees. This finding corroborates Hollnagel (2011; 2014) concept of 'work as imagined' and 'work as done' as two contrasting ways of understanding *Practices* at the "sharp-end". 'Work as imagined' is defined by the *Policies* and *Procedures* outlining the way things should work and represents how program leadership and supervisors believe work happens or should happen. 'Work as done', on the other hand, describes the work as carried out by 'front-line' employees at the 'sharp end'; in the case of collegiate aviation, how flight students and instructors practically engage in flight training activities. The finding corroborates suggestion by Schwarz and Wolfgang Kallus (2015) on a need for resilient safety practices in high operational tempo. Variations in resilient safety culture practices could be due to organizational conditions created by those at the 'blunt end' (management); the *Policies* produced, or the way in which standards for *Practices* are perceived. The results substantiate Paries et al. (2018) assertion that excessive attention to SMS formalism (policy, procedures, and traceability) may lead to bureaucratic processes, often at the expense of focusing on desirable resilient factors such as *Practices.* It is therefore essential for collegiate aviation programs to consider seasonal variation within the flight training environment and calibrate resilient safety culture periodically.

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