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Analysis of airline employees' perceptions of corporate preparedness for COVID-19 disruptions to airline operations

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ABSTRACT

The focus of this research is an analysis of U.S.-based airline employees' responses to corporate preparedness for the COVID-19 disruptions to domestic and international airline operations. A survey was issued during May and June 2020 to U.S.-based employees of major and national carriers and U.S.-based employees from foreign carriers. The research project consists of a questionnaire used to answer the key question: What is your perception of your company's preparedness for and response to the COVID-19 outbreak? Sub-questions address three key areas of employees' responses: 1) Was the airline prepared prior to the pandemic? 2). Did the airline respond appropriately to the pandemic? 3) Is the airline positioned well to recover from the pandemic? Findings indicate that airlines' risk management systems are recognized as a weakness in the organizations; however, they are taking steps to enhance their risk management protocols since dealing with the global coronavirus pandemic. Additional findings indicate that air transport companies need to move away from their reliance on the existing risk management system that is based on historical disruptions and toward a more proactive system. The last finding indicates that knowing and understanding the full potential of the impact of pandemics (or epidemics) may be advantageous in recovering business quickly.

1. Introduction

Historically, external factors have immensely influenced the aviation industry, including the two oil crises in the 1970s and the Gulf War in the 1990s (see A, B, and C in Fig. 1), the September 11th terrorist attack in 2001 (9/11) (see D in Fig. 1), and the financial crises in 1997 and 2008 (see E and F in Fig. 1) [Hong, 2002; Sobieralski, 2020; Suau-Sanchez et al., 2020]. After 9/11, U.S. planes were grounded for less than a week. Within a few days of the resumption of travel, passengers returned, albeit not at pre-9/11 levels (Benoit et al., 2020). During the financial crisis of 2008, travel spending fell sharply as companies and consumers adjusted to the downturn in the economy. In 2002 and 2008, airlines struggled to afford payroll, maintenance, and other fixed costs that run into billions of dollars a day (Benoit et al., 2020). However, the traffic contracted only 1.74% in 2002, which was the worst year after 1972 (−8.18%), and recovered the year after. Airlines reacted quickly to these external disruptions by adjusting capacities and cost levels, but a recovery in profits was slow for many airlines (Franke and John, 2011).

Epidemics (or pandemics) have occurred periodically every two to four years, such as in 2003 (Severe Acute Respiratory Syndrome [SARS]), 2005 (Avian Influenza [Bird Flu or Avian Flu]), 2009 (H1N1 Flu [Swine Flu]), 2013 (Avian Influenza), 2015 (Middle East Respiratory Syndrome [MERS]), and Coronavirus Disease 2019 [COVID-19]. The SARS epidemic had the heaviest impact on traffic volumes. At the height of the SARS outbreak (May 2003), the loss of confidence and fears of a global spread influenced both business and leisure travel to, from, and within the Asia-Pacific region. As a result of SARS, Asia-Pacific Airlines lost 8% of annual revenue-passenger-kilometers and $6 billion of revenues (International Air Transport Association, 2020) [Fig. 2]. Olsen, Chang, Cheung et al. (2003) reported that one infected person of SARS on a flight infected 22 others.

The increasing prevalence of infectious diseases like H1N1 throughout the world, integrated with globalization and the correlated increase in international travel, raised the risk of H1N1 transmissions on airliners (Richter, 2003). Compared with previous pandemics (or epidemics), COVID-19 is spreading more rapidly and severely (Govindan et al., 2020), with the global death toll reaching more than 937,111 as of 9/16/2020 (Johns Hopkins University and Medicine, 2020). Many

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estimates do not expect an economic recovery until at least 2022 (Atkeson, 2020; Curley et al., 2020; International Civil Aviation Organization [ICAO], 2020).

The government- and business-imposed travel restrictions have devastated air travel demand. Since the beginning of March 2020, the U. S. air transport industry—both passenger and cargo—has experienced a financial collapse at an unprecedented pace after growing steadily in January and February 2020. Airline passenger volumes fell over 95%, and cargo carriers were placed on negative watch (Airlines for America, 2020a, pp. 5–6). The sharp decrease in air travel demand is much worse than that seen after 9/11 and the 2008 financial crisis combined (Curley et al., 2020).

As shown in Fig. 3, airline demand in the U.S. was robust and continuously increasing after the financial crisis during 2008 and 2009 until February 2020, when the novel coronavirus emerged. The traffic at all U.S. airports plummeted after United States President Donald Trump issued the proclamation declaring a national emergency due to the coronavirus outbreak on March 13, 2020. Year-over-year changes (YoY) of monthly passenger traffic data in the U.S. varied from a median value of 2.34%–3.99% from January to December 2003 to 2019 (see Table 1). At its maximum in April 2020, U.S. passenger traffic was down −96.23% compared with the previous year. The overall reduction ranges from 44% to 50% of seats offered by airline companies, and the probable loss of total passenger operating revenues of airlines from January to December 2020 is estimated at $343 to $383 billion (ICAO, 2020).

Compared with previous crises, the COVID-19 pandemic leaves even the most vital players vulnerable (Curley et al., 2020). The coronavirus caused many companies to slash capacity, including cutting jobs, grounding jetliner fleets, and parking and/or retiring older aircraft (Jasper et al., 2020). Airlines were using passenger aircraft for cargo-only flights, either belly-only or belly and main cabin (Hong et al., 2018; Pasztor, 2020) and reducing footprints at airport facilities by closing lounges and halting real estate projects (Airlines for America, 2020b). Experts forecast that air travel demand will be highly impacted in the long term (Airlines for America, 2020b; IATA, 2020; ICAO, 2020) due to a diminished demand with lower levels of available revenue aggravated by changes in consumers' behavior. Industry-wide job loss is estimated at 7%–13% of the U.S. airline industry's workforce (Sobieralski, 2020). The hardest hit are those with jobs related to passenger handling and flight operations, while management employees fair slightly better (Sobieralski, 2020).

The lack of consumer confidence when flights resume is a concern for both business and leisure travelers. Teleworking caused by the COVID-19 pandemic is a serious threat to the travel industry, especially for business travelers (Bouwer et al., 2021) and international travelers (Organisation for Economic Co-operation and Development [OECD], 2020). COVID-19 is expected to have less of an impact on leisure travelers, and we would expect to see a faster recovery of demand compared to business travelers (Suau-Sanchez et al., 2020). Finally, the presence of an airport or high-speed train station in a city is significantly related to the speed of the pandemic spread, but its link with the number of total confirmed cases is weak (Sun et al., 2021; Zhang et al., 2020).

The coronavirus pandemic has created a period of great uncertainty; hence our study does not deal with specific recovery scenarios. Instead, the focus is placed on recognizing structural aspects of risk management that may be used by the aviation industry to configure its medium- and long-term responses to sudden changes in customers' air transport needs (Adler and Gellman, 2012). It provides recommendations for risk management, including how to minimize corresponding logistics and supply chain disruptions, especially pandemic-related disruptions, in the airline industry. Within the academic literature, there is limited coverage of the impact of COVID-19 on the airline industry or prospects of recovery (Adrienne et al., 2020; Dube et al., 2021; Suau-Sanchez et al., 2020).

This article examines airlines employees' responses of their company's preparedness for airlines' risk management system, especially during the COVID-19 pandemic. The pandemic primarily impaired front-line airlines' employees at airports who handle passenger and flight operations (Sobieralski, 2020). We studied the front-line employee's preparedness and perception of the risk, especially during the COVID-19 pandemic, to examine the airlines' readiness for the risk. Overall, we have verified the research model for airlines' risk management. The following section provides a literature review on risk management, uncertainty, and COVID-19 as related to the airline industry. Section 3 provides the data analysis, methodology, and framework for the modeling of airlines' risk management plan. Section 4 provides the research results. Section 5 provides theoretical and managerial insight for the air transport industry, airline leaders, and policymakers. Section 6 concludes with research limitations and future works.

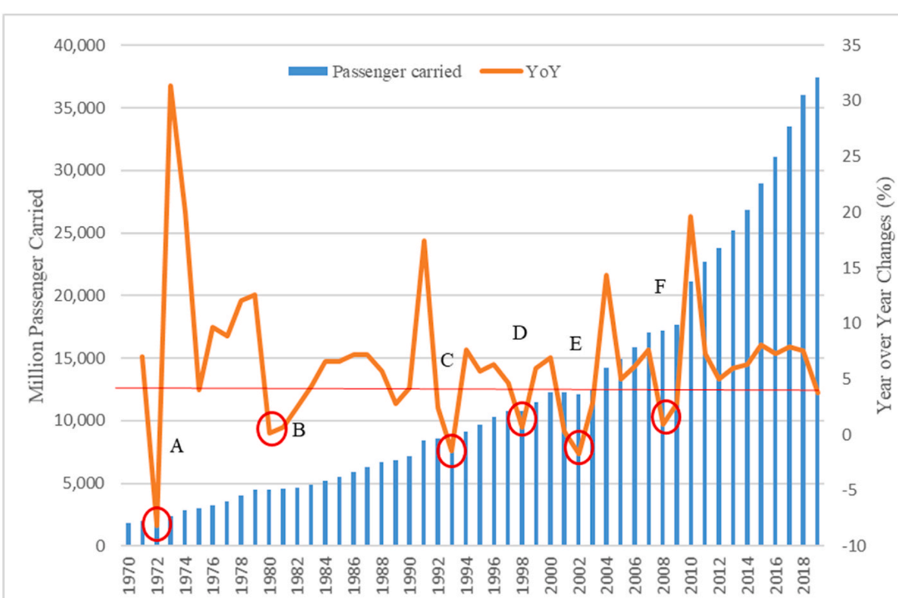

Fig. 1. World air passengers carried an annual growth rate (%) from 1970 to 2019 (World Bank, 2021).

2. Literature review of airlines' risk management plan and COVID-19

2.1. Risk management

Risk Management has become a crucial issue for Chief Executive Officers operating in an uncertain global business environment (Childerhouse et al., 2003; Lee et al., 1997; Li and Hong, 2007). This uncertainty has become a risk management challenge for many global operating business organizations (International Business Machines [IBM], 2008; Sheffi, 2005; Stemmler, 2007) and financial institutions (Altuntas et al., 2011). Risk management has also grown in importance as a result of increased attention in the context of corporate governance (Altuntas et al., 2011). Frequent disruptions and uncertainty from man-made disasters (strikes, terrorist attacks) or natural disasters (e.g., the eruption of volcanic ash in Iceland in 2010, the earthquake and tsunami in Japan, and the flood in Bangkok in 2011) shifted the focus of attention from passive to proactive risk management (Peck, 2007; Sheffi, 2005). The aftermath of the 2011 Japanese earthquake and tsunami led to a rethinking of supply chain disruptions from a different angle of risk management (Financial Times, 2012). The results of natural disasters demonstrate that the view of risk management should be expanded to include various types of uncertainty and risk. Many arbitrary circumstances, such as virus outbreaks, tsunamis, earthquakes, floods, accidents, and financial crises, have just as much impact on a company (Finch, 2004; Sheffi, 2005) as interactive cultural factors (Peck, 2007) or uncertainty (Caggiano et al., 2014) in business environments with partners located all over the world. The rise of pandemics (or epidemics) is now an essential factor to include in risk management plans for public and private organizations.

2.2. Aviation industry and risk management

In the aviation industry, the 9/11 terrorist attack totally changed the paradigm of the aviation business model (Franke and John, 2011) and the risk management of airline companies. Before 9/11, the analysis of risk to airlines was concerned mainly with firm-specific risks and/or internal risks emanating from the industry. Results from this model indicate that risk management drops substantially as airlines approach distress and recover slowly after airlines enter distress (Rampini et al., 2014).

Most large airline companies account for some amount of risk management, primarily highlighting the role of financial constraints in limiting risk management (Benoit et al., 2020; Morrell, 2007; Morrell and Swan, 2006). For example, fuel price hedging significantly mitigates financial risks but has no significant effects on profitability (Merkert and Swidan, 2019). Findings from 16 airline companies during 1997–2002 indicate that debt leverage and organization size are positively related to financial risk while profitability, growth, and safety are negatively associated with systematic risk (Lee and Jang, 2007). Reinforcing risk management practices is one of the key measures for building up financial stability (Altuntas et al., 2011). However, financial risk management, such as hedging (Merkert and Swidan, 2019) and the yield management system (Ma et al., 2019) of airlines facing a pandemic, seems to be useless. Hedging strategies aggravated financial performance instead of reducing their exposure to volatile and potentially rising fuel costs because fuel prices were often below the minimum hedging price (EuroFinance, 2020).

Risk management is a strategic business process where managers need to assess whether the firm's business activities are consistent with its stated strategic ambitions (Nocco and Stulz, 2006), mitigating strategic, financial, hazard, and operational vulnerability (Sheffi, 2005). Risk management through insurance helps only the local optimization of risk management. Although airlines can purchase coverage for a growing number of risks, insurance costs may be prohibitive for some types of risks (Leloudas, 2009). Additionally, while insurance policies cover certain types of risks, there are many uninsured costs for airlines and the industry that are triggered by the occurrence of unforeseen risk-related situations such as the loss of public confidence (Fraser and Simkins, 2010) due to the fear of a novel virus. The damage from the occurrence of a pandemic is not covered by insurance policies.

For airline managers responsible for logistics and supply chain, experience gained from surviving disruptions caused by unexpected risks can be used to reshape their risk management model using four steps: risk management plan, risk factor identification, impact and likelihood analysis, and decision-making (Kim et al., 2004). To get an effective and proactive risk management model, data should be collected from a broad group, and other various statistical methods should be adopted to minimize damage (Pritchard, 2001).

Understanding the risky nature of the airline industry's operations is crucial to effective supply chain management and business governance. The Transportation Research Board of the National Academies provides a framework for enhanced awareness of the level of risk and uncertainty. It is hoped that this framework will motivate a more significant consideration of risk and uncertainty within the decision-making process at the airports and within the airline industry (Kincaid et al., 2012). The framework could increase the company's readiness to deal with unforeseen and unplanned disasters, accidents, and other circumstances. The framework is composed of five key steps: 1. Quantify risk and uncertainty, 2. Analyze cumulative impacts, 3. Prepare risk response

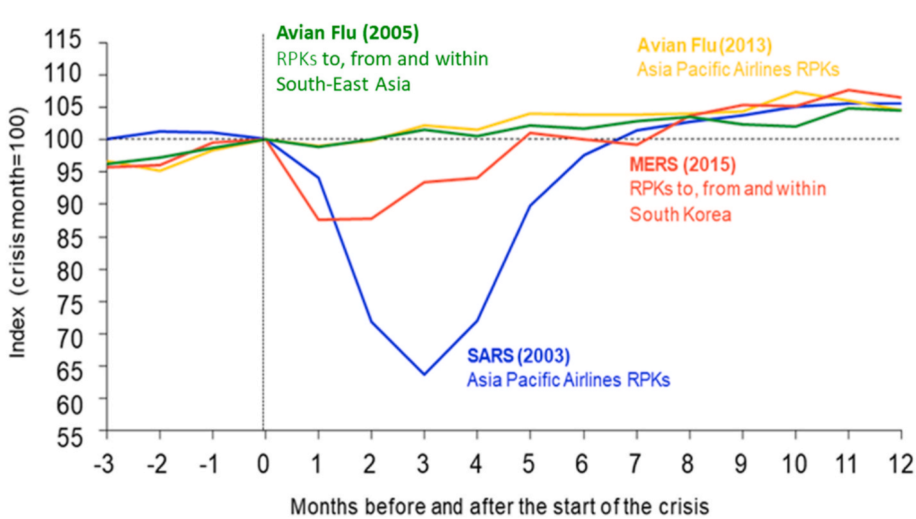

Fig. 2. Past pandemic outbreaks impact on aviation (International Air Transport Association, 2020).

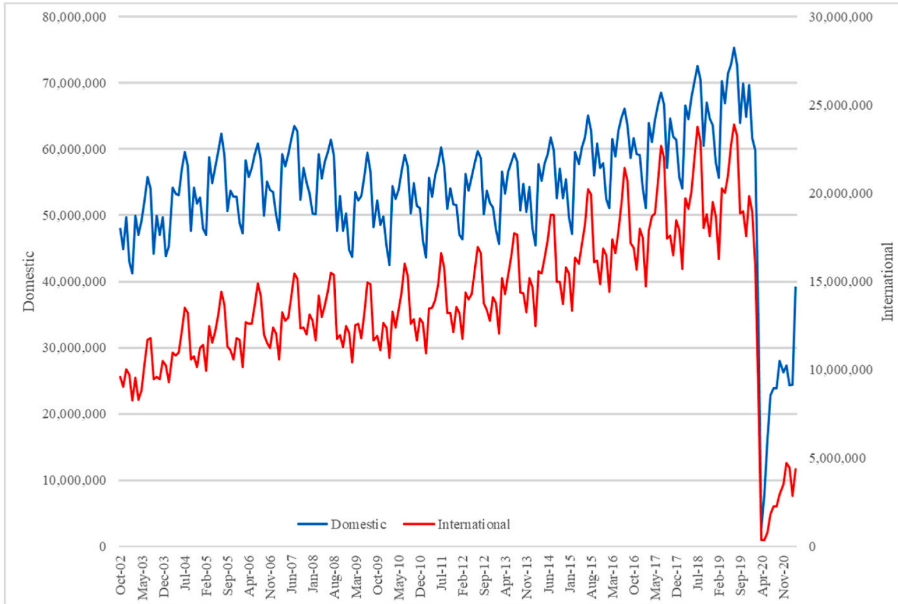

Fig. 3. Air passengers for all carriers at all airports in the U.S. from October 2002 to March 2021 (U.S. Bureau of Transportation Statistics, 2021).

Table 1
Statistics for year-over-year changes (%) of passengers at all airports in the U.S. with all carriers from 2003 to May 2020.

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003 to 2019	Minimum	−9.74	−12.46	−10.07	−5.42	−9.65	−6.63	−3.21	−4.44	−8.05	−6.74	−12.11	−5.51
	25th percentile	1.83	0.39	1.99	1.60	2.50	0.97	0.88	0.39	1.61	−0.14	1.24	0.92
	Median	2.34	2.93	2.98	2.79	3.70	3.24	2.81	2.35	3.99	3.33	3.07	2.47
	75th Percentile	3.88	5.94	4.99	4.37	4.42	4.62	4.66	5.18	5.33	4.50	4.88	4.16
	Maximum	9.80	10.45	9.51	15.74	10.44	10.49	8.30	7.40	8.52	9.04	9.58	7.43
2020		5.02	5.18	−52.09	−96.23	−91.08	−82.27	−75.06	−72.71	−68.45	−65.15	−63.81	−64.30

(Data source, U. S. Bureau of Transportation Statistics, 2021, and authors elaborate).

strategies, 4. Assess risk response strategies, and 5. Monitor the risk and evaluate it (see Fig. 4). Based on the literature review and Fig. 4, we could get our research model as shown in Fig. 5 with risk monitoring, risk evaluation, and risk responsiveness.

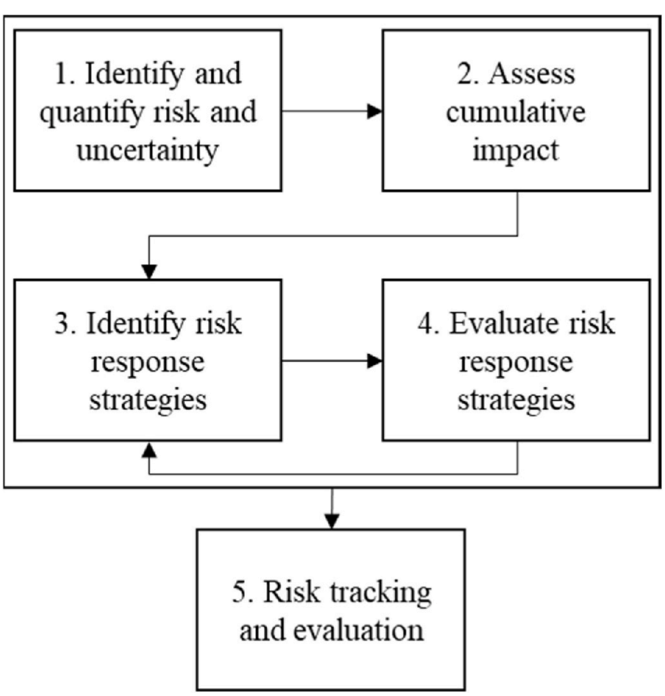

Fig. 4. Risk analysis framework (Kincaid et al., 2012).

3. Data and methodology

For this study, the following steps were used to analyze our research: Step 1: conduct a literature review on risk management attributes for pandemic threats or other risks, such as the 9/11 terrorist attack, 2003 SARS, and 2009 N1H1 pandemics; Step 2: develop survey constructs based on the literature review in step 1; Step 3: gather data from national and foreign air transport carriers; Step 4: conduct a validity test for raw data using normality, homoscedastic, and non-response bias tests; Step 5: analyze exploratory factor analysis and Cronbach alpha test for raw data reliability test; Step 6: build hypotheses and research frame to

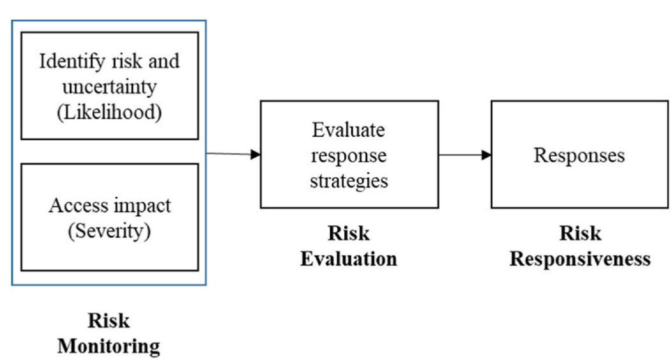

Fig. 5. Research model.

develop a model; Step 7: analyze confirmatory factor analysis and structural equation model (SEM); and Step 8: analyze the preset for the hypotheses and verify.

3.1. Questionnaire

The design of the questionnaire for this study follows Sheffi (2005), Stemmler (2007), Kincaid et al. (2012), Hong et al. (2014), and uses a perception-based measure of a pandemic threat for risk management when facing natural and man-made disasters. Based on the literature review, especially the Transportation Research Board (Kincaid et al., 2012), we have five categories (identify risk and uncertainty based on experience to know risk likelihood [A1], assess impact to find severity [A2], monitor to evaluate response strategies [A3], and responsiveness [A4, A5]).

We simplified the construction of the questionnaire in terms of numbers and words to target front-line US-based employees of airline companies through a pilot test with employees of an airline company in the North Texas area. The questionnaire consists of two segments: (1) a demographic section, and (2) a section of responses on the pandemic threat. The demographic section includes questions about each respondent's job title, work experience in years for the airline (or contract company), and where the respondent works. Fifteen out of 34 (44%) are check-in counter representatives, and five (15%) are maintenance personnel; four (12%) are pilots, and others, such as ground handlers, safety specialists, pricing analyst, aircraft router. Sixty-five percent of respondents have worked with their current employer for less than ten years, and 79% have less than five years with their current job. Nine respondents are from San Francisco International Airport, eight from Dallas Love Field, six from Los Angeles International Airport, four from Dallas-Fort Worth International Airport, and three from Las Vegas Harry Reid International Airport (see Table 2). The response section focused on employees' overall response to the pandemic and included ten questions. The questionnaire was tested using a 5-point Likert scale from one (strongly disagree) to five (strongly agree) for A1 (for A2 to A5, see Table 3).

Table 2
Descriptive statistics for demographics.

Category	Details	*n*	%
Job titles	Check-in counter representatives	15	44.12
	Maintenance personnel	5	14.71
	Pilots	4	11.76
	Ground handlers	3	8.82
	Safety specialists	2	5.88
	Pricing analyst	1	2.94
	Aircraft router	1	2.94
	Others	3	8.82
	Total	**34**	**100**
Work experiences with current employer	1–5 years	10	29.41
	6–10 years	12	35.29
	11–15 years	7	20.59
	More than 16 years	5	14.71
	Total	**34**	**100**
Work experiences with current job	1–5 years	27	79.41
	6–10 years	6	17.65
	11–15 years	0	0
	More than 16 years	1	2.94
	Total	**34**	**100**
Places where the respondent works	San Francisco International Airport	9	26.47
	Dallas Love Field	8	23.53
	Los Angeles International Airport	6	17.65
	Dallas-Fort Worth International Airport	4	11.76
	Las Vegas Harry Reid International Airport	3	8.82
	Others	4	11.76
	Total	**34**	**100**

Table 3
Descriptive statistics for participants' responses of pandemic threats.

Code no.		Pandemic Threat Constructs	Samples			Bootstrap (1)	
			n	Mean	Std. Dev	Mean	Std. Dev
A1	Check your thoughts on the following statements concerning the COVID-19 [1] = Strongly Disagree, [2] = Disagree, [3] = Neutral, [4] = Agree, [5] = Strongly Agree						
	A1a	The pandemic had been forecasted with clear and unambiguous warning signals.	34	2.32	1.007	2.33	0.944
	A1b	Our business unit have experienced similar *pandemic disruptions* before.	34	2.71	1.244	2.99	1.155
	A1c	Our business unit have prepared for similar *pandemic disruptions* before.	34	2.94	1.153	3.00	1.156
	A1d	The scope and speed of the pandemic *surprised us*.	34	3.74	1.263	3.60	0.921
A2		When the outbreak of COVID-19 occurred in China in January, how much impact did you think the pandemic would have on your business unit? Significantly Smaller [1], Smaller [2], Larger [4], Significantly Larger [5]	34	2.35	1.368	2.33	0.943
A3	How long did it take to address the following events in each stage? Very slow [1] = more than a month, Slow [2] = month, Moderate [3] = week, Fast [4] = less than week, Very fast [5] = hours						
	A3a	**Recognition**: The time to recognize that there is a threatening situation.	34	3.18	1.167	2.99	1.156
	A3b	**Diagnosis of the Situation**: Time for information-gathering and interpreting the magnitude, location and causes.	34	3.09	1.264	3.00	1.155
	A3c	**Development of a Response**: The time to identify, formulate and evaluate a set of possible responses.	34	3.41	1.076	3.50	0.867
	A3d	**Response Implementation and Recovery**: The time to implement an action and restoration plan to the desirable state.	34	3.12	1.343	3.00	1.155
A4	Choose one of following statements of your company's (or your section's) response to the COVID-19?						
	A4a	**No Action to Response**: We did not take any specific action to the COVID-19.	32	15.6(2)	15.6(3)	14.1(2)	14.1(3)
	A4b	**Routine Process to Response**: The COVID-19 was under our routine response repertoire.		15.6(2)	31.3(3)	25.2(2)	39.3(3)

(continued on next page)

Table 3 (*continued*)

Code no.	Pandemic Threat Constructs	Samples			Bootstrap [(1)]	
		n	Mean	Std. Dev	Mean	Std. Dev
A4c	**Non-Routine Process to Response**: We had a new response system particularly for the COVID-19.		68.8[(2)]	100[(3)]	60.7[(2)]	100[(3)]
A5	How much effort did you perceive your business unit put into resolving the disruption? [1] = Very Little, [2] = Little, [3] = Moderate, [4] = Much, [5] = Very Much	33	3.76	0.792	3.77	0.642

(1) Monte Carlo simulation—Double bootstrap method applied and 100,000 data generated.
(2) Percent of choosing for A4a, b, c.
(3) Cumulative percent for A4.

3.2. Data collection

The survey was distributed during May and June 2020. The survey participants were chosen based on our colleague network, primarily based on the alumni network of aviation logistics departments. A snowball sampling method was applied for major and national carriers using an online survey tool (Qualtrics). Foreign carriers were contacted through direct email. The snowball sampling method consists of two steps, 1) try to contact one or two colleagues and (or) alumni at the region or specified airport, 2) ask those colleagues and (or) alumni to recruit another one to three people who work in the same area. We collected the results very shortly after the distribution because the pandemic had begun to spread quickly and widely; it also increased stress for the employees since airlines had been forced to park hundreds of planes and consider tens of thousands of job cuts. We received a total of 34 responses, 15 from U.S.-based employees of major and national carriers and 19 U.S.-based employees from foreign carriers. We applied a Monte Carlo simulation to minimize possible bias with a small number of samples.

3.3. Monte Carlo simulation

The simulation was used to estimate employees' responses to the pandemic threat, θ, with an estimator, $\widehat{\theta}$, computed from observed data. The estimators must meet important and intuitive criteria, unbiasedness, efficiency, and consistency (Mooney, 1997). Monte Carlo (MC) simulations are applied by researchers to ascertain the robustness of statistical estimators (Chin et al., 2003) because of randomness and no noise of the data generating process (Simar and Wilson, 2007). The MC simulation is very similar to resampling. It refers to resampling methods (Carsey, 2011) using computers to generate a large number of simulated samples drawn from an existing sample of data.

Our observed data included a limited number (34 samples) to describe and make inferences. MC simulation is a random number generator that creates artificial data risk analysis and risk quantification (Mun, 2006). The hundreds of thousands of simulated data based on small observed data could solve the problem of biased sampling or low response rates of surveys (Gustavson et al., 2019). Based on the MC procedure (Mooney, 1997), we sampled t times from the pseudo-population ($\widehat{\theta}$) to better estimate the response of a pandemic threat using the statistical estimates derived from the real data $\widehat{\theta}$ and store it in a vector $\widehat{\boldsymbol{\theta}}$. We use capital letters for random variables ($\widehat{\Theta}_j$), $j = 1, \ldots t$. The sample size t includes 1,000 sets of data retrieved from upward of 1,000 trials (Mooney, 1997) and generated 100,000 data points (see Table 3).

3.4. Raw data validity tests using normality, homoscedastic test, and non-response bias test

All relevant tests have been subject to bootstrapping with 5,000 samples because of the non-normality of datasets. All of the research variables are applied using Shapiro-Wilk's test for normality and Levene's test for heteroscedastic. Most of the variables (seven[1] out 11) are heteroscedastic. For the non-response bias test, we used a hypothesizing method using different steps for respondents that were presumed to be closer to non-respondents between survey participants in different time waves (Armstrong and Overton, 1977). We issued surveys in two different time waves with a one-week difference. The first wave was distributed from May 22 to June 4 using email and collected 19 samples for foreign carriers' front-line employees based at the Dallas-Fort Worth, Los Angeles and San Francisco airports. The second wave, from June 10 to 23, 2020, received 15 samples through an online survey tool (Qualtrics) for airline employees based in the North Texas area and Las Vegas, Nevada. The *t*-test bootstrapping (5,000 samples) results show that seven[2] out of 11 variables were not statistically or significantly different between the two groups with a *p*-level of 0.05, which signifies that non-response bias was not found in our raw data.

3.5. Exploratory factor analysis

Exploratory Factor Analysis (EFA) was extracted using the principal component analysis (PCA) and rotated with Varimax with Kaiser normalization after correlation analysis, referring the linear relationship among variables (Table 4). The three extracted principal components can explain 68.3% of the total variance in the items, such as risk responsiveness, risk evaluation, and risk monitoring. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (0.723) and Chi-square (χ^2: 174.334, sig. = 0.000) are statistically significant (see Table 5).

3.6. Reliability test

Cronbach's alpha, [α], and composite reliability [CR]) is above 0.800, which is significant statistically except for the component of risk evaluation (0.728). According to Goforth (2015), CR and α coefficient is acceptable above 0.70, and less than 0.5 is usually unacceptable. We use the component (Risk evaluation) even though the α coefficient is not at the level of excellent (0.800) but is acceptable with a high explainability (19.9%) [See extraction sum in Table 5].

3.7. Average Variance Extracted

Average Variance Extracted (AVE) is a measure of the amount of variance captured by a construct in relation to the amount of variance due to measurement error. The AVE has often been used to assess discriminant validity, which is established at the construct level. According to Fornell and Larcker (1981), if the values are above 0.7 (Risk monitoring) they are considered very good, whereas the level of 0.5 (Risk responsiveness and evaluation) is acceptable.

3.8. Confirmatory factor analysis

From the EFA result, we created two research models (1 and 2) with three latent variables: Risk responsiveness (RR), including diagnosis of

[1] A1a, A1b, A1c, A1d, A3a, A3b, A4.
[2] A1a, A1b, A1c, A1d, A2, A3a, A4.

Table 4
Correlation analysis of the variables.

	A1a	A1b	A1c	A1d	A2	A3a	A3b	A3c	A3d	A4	A5
A1a	1										
A1b	−0.212	1									
A1c	−0.192	0.685[b]	1								
A1d	0.212	0.180	−0.094	1							
A2	0.377[a]	−0.186	−0.121	0.214	1						
A3a	0.543[a]	−0.548[b]	−0.487[b]	0.156	0.526[b]	1					
A3b	0.215	−0.137	−0.225	0.300	0.174	0.236	1				
A3c	−0.043	−0.156	−0.200	0.150	−0.040	0.037	0.796[b]	1			
A3d	0.150	−0.178	−0.250	0.251	0.191	0.257	0.850[b]	0.741[b]	1		
A4	0.236	−0.177	−0.348[a]	0.419[a]	0.068	0.370[a]	0.556[b]	0.384[a]	0.597[b]	1	
A5	−0.212	0.071	−0.131	0.304	0.186	0.044	0.354[a]	0.324	0.454[b]	0.344[a]	1

[a] Significant at 0.05 (2-tailed).
[b] Significant at 0.01 (2-tailed).

Table 5
Exploratory factor analysis and reliability test results.

Item No.	Latent variables	Selected Constructs of Pandemic Threat	Components			Reliability Test		AVE (2)
			1	2	3	Cronbach's α	CR (1)	
A3b	Risk Responsiveness	Diagnosis of the Situation	**.884**	.122	-.137	0.854	0.890	0.624
A3c		Development of a Response	**.838**	-.217	-.185			
A3d		Response Implementation and Recovery	**.893**	.104	-.167			
A4		Your business unit's response to the COVID-19	**.674**	.303	-.155			
A5		How much effort did you perceive your business unit put into resolving the disruption?	**.620**	.044	.187			
A1a	Risk Evaluation	The pandemic had been forecasted with clear and unambiguous warning signals.	-.015	**.748**	-.204	0.728	0.777	0.538
A2		How much impact did you think the pandemic would have on your business unit?	.058	**.746**	-.049			
A3a		Recognition—The time to recognize that there is a threatening situation.	.104	**.706**	-.542			
A1b	Risk Monitoring	Experienced similar *pandemic disruptions* before.	-.033	-.125	**.916**	0.811	0.835	0.718
A1c		Prepared for similar *pandemic disruptions* before.	-.220	-.174	**.772**			
Extraction sums of squared loading (%)			35.5	19.9	12.9	(68.3)[a]		
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity			0.723 and χ^2: 174.334 (0.000[b])					

(1) CR: Composite Reliability.
(2) AVE: Average Variance Extracted.
[a] Total extraction sums of squared loading (%).
[b] Significant at 0.001.

the risk; Risk evaluation (RE), and Risk monitoring (RM). The selected constructs and latent variables were analyzed through traditional Confirmatory Factor Analysis (CFA), applying SPSS Analysis of Moment Structures (AMOS). We applied each item as a separate measure of the applicable construct, thus providing an all-inclusive level of analysis. Model 1 (left of Fig. 6) is not a good fit as a research model. Based on Hu and Bentler's (1999) criteria, Model 2 (right of Fig. 6) is a better fit for aviation risk management in the U.S., especially for the service area, as it evaluated and accepted the models significantly as an excellent or acceptable fit (see Table 6).

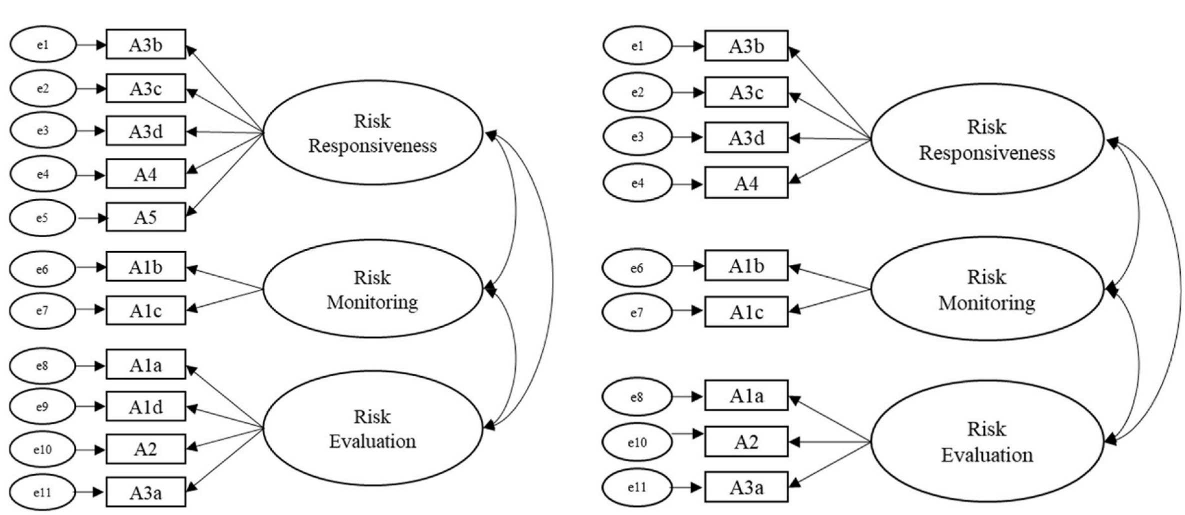

Fig. 6. Research Models 1 (Left) and 2 (Right) based on survey.

Table 6
Confirmatory factor analysis results for risk management at aviation academy.

Evaluating the Model Fitness		Model 1		Model 2		Threshold for excellent [(1)]
Category	Index	Estimate	Interpretation	Estimate	Interpretation	
Parsimonious fit	χ^2/df	1.133	Excellent	1.011	Excellent	Between 1 and 3
Absolute fit	Goodness of Fit Index (GFI)	0.806	Terrible	0.909	Acceptable	>0.95 (>0.90[(2)])
	Root Mean Square Error of Approximation (RMSEA)	0.063	Acceptable	0.000	Excellent	<0.06 (>0.06[(2)])
	p of Close Fit (PClose)	0.389	Excellent	0.801	Excellent	>0.05
Incremental fit	Normed Fit Index (NFI)	0.896	Terrible	0.913	Acceptable	>0.95 (>0.90 [(2)])
	Comparative Fit Index (CFI)	0.963	Excellent	1.000	Acceptable	>0.95

(1) Source: Hu and Bentler (1999).
(2) Threshold for acceptable.

4. Research results

The survey and generated data show U.S.-based employees' responses of the aviation industry regarding the impact of COVID-19, especially for front-line workers. The scope and speed of the pandemic provide a picture of the revelation resulting from the reduction in air travel demand and impact, as well as the quick spread of fear and loss of confidence to fly. The airline companies and their employees did not have proactive policies in place to recognize, nor appropriate procedures in place to respond to, the coronavirus. However, based on survey responses, the aviation industry did its best to use non-routine processes to keep the spread of the virus under control. This was necessary to reduce customers' fears and allow them to regain their confidence to fly. Our findings, based on EFA and CFA, indicate that three attributes— risk responsiveness, risk evaluation, and risk monitoring – will make for more vital risk management in dealing with future pandemics (or epidemics).

4.1. Risk monitoring

Risk Monitoring analyzes the likelihood and the impact of risks on an organization (Pritchard, 2001). All possible risks for an organization have to be shaped comprehensively. The risk identification process mainly encompasses the definition of internal and external factors influencing the risks along with the corresponding values, which in turn are influenced by other risks (Altuntas et al., 2011). In the succeeding stage, risks are accessed and categorized into controllable (or acceptable) and uncontrollable (or unacceptable) risks, which should later be either analyzed and monitored separately.

4.2. Risk evaluation

Risk Evaluation should be monitored on an ongoing basis, and a strategic plan for risks needs to be reviewed periodically. This stage includes communications, which involves sharing relevant, risk-related information across an organization's departments (Meulbroek, 2002), especially related to the overall supply chain. Continuous evaluations allow a company's risk management process to be monitored and modified for future disruptions. Evaluating the risk management plan may be aimed at avoiding unforeseen risks by mitigating the activities that generate particular risks or alleviating the likelihood or impact of potential uncertainty or disruption on supply chain operations.

4.3. Risk responsiveness

Risk Responsiveness can be elaborated based on the preceding evaluation of risks, recognizing the organization's risk objectives. This step includes the governing pursuit phase involving the creation of policies and procedures to ensure that proper risk responses are integrated into the management structure of the organization. The process of risk management should be put in place across all organizational departments. It should range from particular projects such as supply chain agility to assisting with determining overall management response.

Based on the survey and generated data, we deployed a structural equation model (SEM) with the three research attributes discussed above. We found a statistically acceptable model (Table 7) to measure the relationship between risk monitoring, risk evaluation, and risk responsiveness (Fig. 7).

4.4. Study 1 for the relationship between risk monitoring and risk responsiveness

Leading companies take a robust, rigorous, and forward-looking approach to risk management, which calls for an assessment of the financial stability of public and private suppliers (PriceWaterhouseCoopers, 2009). A continuous risk monitoring approach that begins with identifying likelihood, severity, and early involvement is key to averting and reducing the impact of disruption and risk on the supply chain as well as the overall operations of the enterprise (FAA, 2009). Risk responsiveness is about an airline's ability to protect and recover its operation from the potential human errors and natural disasters (Macrae, 2014; Sheffi, 2005). Thus, the first study for the risk management of airlines is the relationship between risk monitoring and risk responsiveness.

4.5. Study 2 for the relationship between risk evaluation and risk responsiveness

Proper risk evaluation allows for adequate responses to various risk scenarios. The procedure evaluation includes recognizing potential disruptive situations based on detailed risk models and the maturity of strategic decisions to the response. The evaluation of risk is an essential factor of risk management (FAA, 2009). Thus, the second study for the risk management of airlines is the relationship between risk evaluation and risk responsiveness.

Based on the SEM analysis, we found that studies 1 and 2 are not statistically significant (Study 1: RM → RR; Study 2: RE → RR) [see Table 7]. These findings indicate that the routine procedures for risk management have been minimally applied for the exogenous factor—pandemics.

Table 7
Structural equation model for airlines' risk management.

Research Path		Coefficients	Results
Study 1: Risk Monitoring → Risk Responsiveness		0.047	Not supported
Study 2: Risk Evaluation → Risk Responsiveness		0.086	Not supported
Goodness of Fit Measures		Estimate	Interpretation
Parsimonious fit	χ^2/df	1.021	Excellent
Absolute fit	GFI	0.923	Acceptable [(1)]
	RMSEA	0.025	Excellent
	PClose	0.492	Excellent
Incremental fit	NFI	0.904	Acceptable [(1)]
	CFI	0.998	Excellent

(1) See Table 6 for the threshold for excellent.

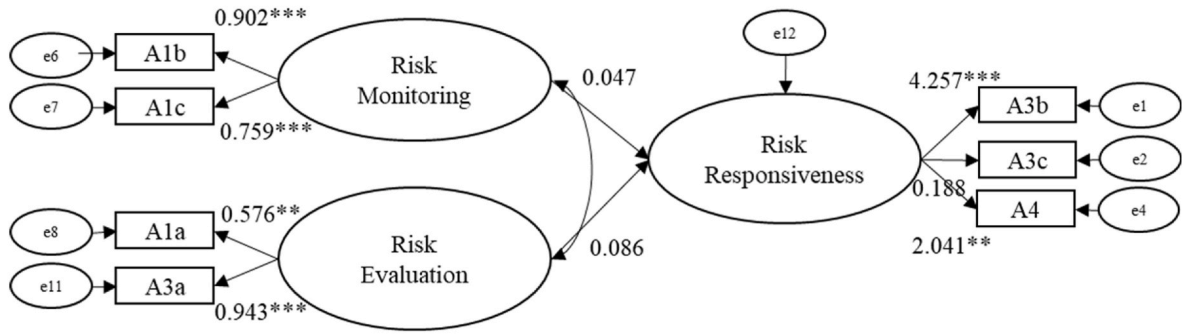

Fig. 7. Structural equation model for airlines' risk management with standardized regression weight and covariance of research attributes.

5. Theoretical and managerial implications

Based on these findings, the air transport industry needs to shift its risk management paradigm facing new phenomena, such as the coronavirus outbreak. Airlines' management and employees realize the increased risk of having a critical failure due to a pandemic. The airline industry is highly susceptible to the external operating risk environment that is triggered by many uncontrollable external factors (war, threat of terrorists, outbreak of disease, market recession, and high fuel prices) [Lee and Jang, 2007] that are covered by insurance policies. However, consumers' fear of pandemics is not covered by insurance policies. Thus, a more robust approach requires working closely with public health organizations to obtain vital information that is not publicly available but is needed for risk analysis and enables the air transport industry to prepare for adjustments in its business operations. Suppose an airline fails to search risks for not only internal factors but also external factors that are not experienced. In that case, it is likely that the airline industry will neither recover quickly nor have resiliency.

Uninsurable events, like pandemics, are high severity and low frequency but are expected to be more frequent in the future. The airline industry needs to establish effective risk management systems that can address this future state and enhance the agility of their global supply chain to minimize the length and severity of the disruption. Fear of the pandemic spread rapidly and spurred drastic changes in customers' intent to travel via air and their choice of tourist destinations. As with previous virus outbreaks, to regain customers' confidence, passenger airlines should sanitize cabins daily and emphasize the importance of routine disinfection services (Chou and Lu, 2011).

Our findings indicate that the existing risk management systems of airlines were not equipped to deal with the disruptions caused by the COVID-19 pandemic. The coronavirus had not been anticipated or forecasted by their current models and surprised the air transport industry in terms of the scope and rapid speed of disruptions to its operations and subsequent damage to global supply chains, including aircraft manufacturers and airports (OECD, 2020). Domestic and foreign airline companies simply did not have appropriate response procedures and safety measures, such as disinfection, personal protection equipment, temperature checks, or viral tests, in place to deal with this level of disruption. Many airline companies received government aid or government-backed loans to meet payroll and other obligations to sustain their business operations during the coronavirus outbreak (Jasper et al., 2020; OECD, 2020). Knowing and understanding the potential of the impact of an unforeseen situation, such as the COVID-19 pandemic, may allow for strengthening the resilience of the supply chain and be advantageous in recovering business quickly.

6. Conclusion with research limitations and future research

The shakeout during the coronavirus outbreak will bring a variety of carriers to bankruptcy and seriously reduced consumers' travel. Bankruptcies and reduced travel demand may lead to the long-term or permanent grounding of significant numbers of aircraft and employee layoffs (Jasper et al., 2020). The global recession caused by COVID-19 and weak consumer confidence will continue to slow the recovery in air travel demand (IATA, 2020). The air transport industry may not return to its comfortable pre-COVID-19 conditions for a long time (Jasper et al., 2020).

Airlines and airplane manufacturers are mounting a major push to build confidence among travelers (McCartney, 2020). However, for passenger airlines, they should consider which resources, such as human and material, as well as appropriate procedures, execution, and monitoring systems must be available, allowing them to respond quickly. Executing an appropriately performing risk management system has become paramount. Airlines must work jointly with public health organizations and with their own risk management system, to include safety requirements and innovative technologies before facing a new pandemic.

Airlines' risk management plans and systems should evolve over time from handling operational accidents, incidents, or financial risks, such as fuel price hedging, to structured programs that form integral risk management systems (Hong, 2003). Unlike traditional risk management plans, where individual risks are managed in separate silos, new risk management systems must evolve from the idea of executing all pertinent risks in an integrated, extensive fashion (Altuntas et al., 2011). The existence of devoted risk functions at managerial levels in organizations, such as the Chief Risk Officer and its analogues or integrative risk management committees, are responsible for risk management systems in their organizations (Walker et al., 2003). Official endorsements of C-level managers foster an organization-wide evolution of beneficial risk cultures (Altuntas et al., 2011; Hong et al., 2016; Kim et al., 2004). Company-wide risk management attempts to mitigate the likelihood of sizeable gloomy earnings and cash flows by harmonizing and commanding balancing risks across the organization (Altuntas et al., 2011). We believe our research will strengthen the global supply chain, allowing airlines to anticipate future disruptions better and recover faster when such disruptions occur.

Because of the airline industry's high susceptibility to the effects of pandemics and other disruptions, future research should delve more deeply into how the aviation supply chain might more efficiently prepare for future pandemics (or epidemics). Specific research areas could include hardening and increasing the agility of the global supply chain, developing proper handling procedures for when a pandemic or other unexpected disruption occurs, and identifying efficient and effective ways to quickly analyze the findings and impacts for an improved systematic risk management plan.

Subsequent studies might also attempt to identify other risk factors that are associated with pandemics to increase the robustness of the aviation industry's risk management model with larger samples, including different regions' airlines. Because of this limitation, the research models of this research are cautioned.

CRediT authorship contribution statement

Seock-Jin Hong: Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Visualization. **Michael Savoie:** Conceptualization, Methodology, Validation, Writing – original draft, Supervision, Project administration. **Steve Joiner:** Conceptualization, Methodology, Investigation, Writing – review & editing. **Timothy Kincaid:** Conceptualization, Investigation, Writing – review & editing.

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