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A qualitative systematic review on the application of the normalization of deviance phenomenon within high-risk industries

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ABSTRACT

Introduction: The concept of normalization of deviance describes the gradual acceptance of deviant observations and practices. It is founded upon the gradual desensitization to risk experienced by individuals or groups who recurrently deviate from standard operating procedures without encountering negative consequences. Since its inception, normalization of deviance has seen extensive, but segmented, application across numerous high-risk industrial contexts. The current paper describes a systematic review of the existing literature on the topic of normalization of deviance within high-risk industrial settings. *Method*: Four major databases were searched in order to identify relevant academic literature, with 33 academic papers meeting all inclusion criteria. Directed content analysis was used to analyze the texts. *Results:* Based on the review, an initial conceptual framework was developed to encapsulate identified themes and their interactions; key themes linked to the normalization of deviance included risk normalization, production pressure, culture, and a lack of negative consequences. *Conclusions:* While preliminary, the present framework offers relevant insights into the phenomenon that may help guide future analysis using primary data sources and aid in the development of intervention methods. *Practical Applications:* Normalization of deviance is an insidious phenomenon that has been noted in several high-profile disasters across a variety of industrial settings. A number of organizational factors allow for and/or propagate this process, and as such, the phenomenon should be considered as an aspect of safety evaluations and interventions.

1. Introduction

In January of 1986, after only 73 seconds of flight, Space Shuttle Challenger broke apart above the Atlantic Ocean. Following the incident, a Presidential Commission was established with the aim of uncovering the contributory factors and causes of the disaster. On a technical level, the vehicle's disintegration stemmed from the failure of eroded O-ring seals. This failure enabled the leakage of hot gas from the right booster rocket, culminating in structural collapse (NASA, 1986). Given the distinct and apparently avoidable nature of the failure, the question of why the issue had not been addressed at an earlier stage prompted an investigation into the broader context of the disaster, with a specific focus on the organizational factors that enabled the shuttle to be deemed safe for launch.

The nature of the disaster, coupled with revelations regarding NASA's organizational culture, led to the coining of the term 'Normalization of Deviance' (NoD) as a means of describing an individual/group's general acceptance of deviant actions or observations (Vaughan, 1996). Since its inception, the concept has seen extensive application across a broad range of industrial sectors and has been used to explain a number of other high-profile industrial incidents (e.g. Texas City Refinery [Dechy, Dien, Marsden, & Rousseau, 2018], Northwick Park drug trial [Hedgecoe, 2014]). To date, an extensive synthesis or compilation demonstrating the state of the literature has not been conducted. This is particularly noteworthy given that the category of high-risk industry is broad and highly varied, encompassing a diverse range of production aims, operating environments, and associated risks. As such, a systematic review across this category is needed to critically analyze and present how the concept of NoD has been applied within different settings and examine whether differences exist in the proposed theory, application, or intervention.

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1.1. The Space Shuttle Challenger Disaster

A key finding outlined by the investigation into the Space Shuttle Challenger Disaster was that NASA and their engineers were in fact aware of the vehicle's structural weakness. Signs of erosion on the primary O-rings (rubber seals preventing the escape of hot gases between booster rocket segments) had been noted in 14 of the previous 24 missions across a period of 5 years (Starbuck & Milliken, 1988). In 9 of the final 10 flights prior to the disaster, engineers noted erosion on the primary O-rings, as well as evidence of gas leakage in most of these latter cases. The extent of the damage was further exemplified by evidence of erosion on the secondary O-rings, which represented a final safety mechanism and served as a redundant backup (NASA, 1986). These issues were highlighted by engineers on multiple occasions, however, NASA managers failed to implement corrective measures, deeming the risk of potential O-ring failure to be acceptable. Following the disaster, one of the managers responsible for the operations of the solid rocket boosters stated:

> *'Since the risk of O-ring erosion was accepted and indeed expected, it was no longer considered an anomaly to be resolved before the next flight ... the conclusion was, there was no significant difference in risk from previous launches. We'd be taking essentially the same risk on Jan. 28 that we have been ever since we first saw O-ring erosion.'* (Bell & Esch, 1987, p. 44, 47)

While the presence of the problem and its implications were acknowledged, the prior accumulation of successful launches fostered a tolerance towards the risk posed, enabling the issue to become relatively normalized. In spite of the increasing frequency and magnitude of erosion, as well as evidence of improper functioning, sub-contractor Thiokol suggested to NASA that the O-ring situation be considered 'closed' (Starbuck & Milliken, 1988). They presented the belief that it did not endanger flight safety and that the problem would not be resolved any time soon. This is particularly noteworthy given that the O-rings had previously been categorized as a "Criticality 1" component, wherein the component's failure is deemed likely to result in the loss of life or vehicle (NASA, 1986). Though the Criticality 1 of the O-rings was acknowledged as a launch constraint, it was consistently waived and rationalized as acceptable in light of prior mission successes (Starbuck & Milliken, 1988). Even on the eve of the launch, sub-contractor engineers who expressed concern over the potential for improper sealing under the low forecasted temperatures (−1 °C) were informed that they would need to provide evidence for their claims (Starbuck & Milliken, 1988). The engineers did not have enough data to determine the adequate functioning of the O-rings below 12 °C due to a lack of tests. This was not regarded by the leadership as an adequate cause for delaying the launch, a reluctance likely exacerbated the occurrence of multiple previous delays (Starbuck & Milliken, 1988).

1.2. Normalization of Deviance (NoD)

Within organizational contexts, safety culture describes an organization's collective underlying employee beliefs and values regarding personal and group responsibilities for safety and risk management (Everson, Wilbanks, & Boust, 2020). In reviewing the course of events preceding the Challenger disaster, it appears the O-ring failure merely represents the final fault within a sequence of issues on part of NASA's organizational system. Internal pressures stemming from financial costs, efficiency, political, and managerial demands, in concordance with increasing complacency and overconfidence, compromised the organization's safety culture and facilitated patterns of procedural deviations and risk acceptance (Vaughan, 1996). Diane Vaughan, a sociologist investigating the latent causes of the Challenger incident, coined the term 'Normalization of Deviance' (NoD) to describe how the compromised safety culture of NASA propagated itself to the point of disaster.

Vaughan (1996) defined NoD as the gradual process wherein, in the absence of perceived losses or harm, deviant practices become acceptable. A prominent feature of the phenomenon is the desensitization process, wherein frequent engagement in deviant practices facilitates the practice's normalization and perceived standardization within everyday operations. This normalized perception sets a new precedent for what is viewed as tolerable and routine, establishing a new normal from which further deviations may occur. In the absence of external intervention (e.g., external audits, change in procedures), this cycle of deviance is disrupted only when deviant behavior incurs an undesirable outcome.

According to Vaughan (1996), this process of normalized deviance provided the foundation for the Challenger disaster. The theory speculates that successes in the absence of overt negative consequences may cause an organization's members to develop overconfident perceptions of infallibility towards their existing programs, procedures, and leadership. In the case of the Challenger, risks associated with the shuttle's structural flaws, though likely a cause for concern to external observers, became imperceptible to many within the organization itself. Dillon, Rogers, Madsen, and Tinsley (2013) showcase this phenomenon in a temporal mapping of shuttle mission anomalies reported before and after each of the major disasters of the NASA program: Challenger in 1986, and Columbia in 2003. Data indicate a downward trend in reported anomalies over time, with initial missions displaying a far greater incidence of reporting by comparison to subsequent missions that preceded the disasters. The authors suggest the decrease in anomaly reporting likely resulted from anomaly normalization rather than resolution. With the accumulation of successful missions, some occurrences initially deemed anomalous became accepted as normal facets of operations and were no longer reported; implying that the more frequently an anomaly or near miss was observed without serious consequence, the greater the perception that no significant threat was being posed.

The progressive downgrading of anomaly importance was also discussed in the report published by the Columbia Accident Investigation Board (CAIB) (2003) following the Space Shuttle Columbia disaster. As with the Challenger, the downing of the Columbia resulted from a known issue; the shedding of insulation foam from one of the fuel tanks, previously observed within at least 30 prior missions (CAIB, 2003). While originally considered an in-flight anomaly, it does not appear to have been deemed a serious risk to flight safety. In fact, the frequency of observed shedding caused its significance to be downgraded from an in-flight anomaly to a so-called 'action item' only months prior to the disaster (CAIB, 2003). On the first of February 2003, a piece of foam debris hit the wing of Space Shuttle Columbia, puncturing a hole in the leading edge of the wing, and causing damage which proved terminal upon re-entry into the atmosphere.

1.3. System approach

Following the aftermath of the Challenger disaster, work by Vaughn proved a crucial contribution to the growing literature looking into accident causation as a product of complex systems. Banja (2010) notes that major disasters such as those of the space shuttles cannot be attributed to singular actions or individuals. They instead require the commission of numerous, often innocuous, mistakes that breach the organization's defenses. On this basis, it was understood that investigations and interventions should focus on systematic or latent errors, rather than attempt to pinpoint active individual errors. Reason (2000) describes how these latent errors foster an environment where error-provoking conditions (e.g., time pressure, inexperience) increase the likelihood of active failures (e.g., slips, procedural violations), whilst also undermining established safety measures that typically prevent hazards from resulting in losses (e.g., untrustworthy alarms, poorly designed procedures). The shuttle disasters, though physically speaking the product of technical failures, stemmed from issues relating to cognitive biases (i.e., the human vulnerability for systematic errors in information processing, perception and subsequent decision making; Kahneman, 2011). High-risk environments such as that of NASA, where technical problems and anomalies are part of the norm rather than an exception, are therefore particularly vulnerable to fostering desensitized perceptions of risk.

1.4. Industrial application

Following its inception within the aerospace industry, the concept of NoD has seen widespread application across numerous other high-risk industries, including oil and gas (Bogard, Ludwig, Staats, & Kretschmer, 2015), nuclear (Sanne, 2012), aviation (Paletz, Bearman, Orasanu, & Holbrook, 2009), and healthcare (Banja, 2010). As in the space shuttle disasters, the concept has been utilized to explain how deviant behaviors may become normalized within organizational contexts. Individuals engaging in deviant actions often appear largely unaware of their deviations or feel their deviance is justified; in either instance, their ability to accurately perceive and comprehend risk is compromised (Banja, 2010; Cavnor, 2018; Hase & Phin, 2015). Given the hazards, intrinsic safety concerns, and production pressures prevalent among high-risk industries and work environments, there is considerable interest in understanding the human mechanisms that may unknowingly propagate and facilitate unwanted outcomes.

Reviews of research into other phenomena such as teamwork and design characteristics have highlighted the significance of context-based variations with regards to industrial factors such as technology level, the focus of service, and the nature of production (Carter et al., 2019). To fully understand and utilize the NoD concept it is therefore important to synthesize research across a number of relevant high-risk domains to help ascertain the boundaries of the phenomenon and identify relevant commonalities, potential outliers, and general areas of interest that may help guide future research and intervention.

1.5. Aim

In recent years there has been a notable increase in the number of research papers on the topic of NoD from within various industry contexts. However, the majority of this research has been conducted independently and in isolation, with a lack of a defined overall theory. The present systematic review has the following objectives:

- Synthesize the existing literature in order to identify commonly discussed themes and components relevant to normalization of deviance.
- Determine the extent to which the central concept and associated factors can be generalized across high-risk industrial contexts.
- Identify gaps in the literature and develop suggestions for future research directions.
- Develop a preliminary conceptual model that would represent the manifestation and propagation of the NoD phenomenon within high-risk industry contexts.

2. Method

2.1. Search method

The literature search was conducted in February 2021. Four major databases were searched (Scopus, ProQuest, Web of Science, and Science Direct), using search terms: "normalization of deviance" OR "risk normalization" OR "normalization of risk" OR "deviance normalization" OR "normalization of deviance" OR "risk normalization" OR "normalization of risk" OR "deviance normalization." Risk normalization terms were included in the search criteria due to the concept's close association with NoD. All search results were then compiled, with all inter and intra database duplicates removed. The total number of unduplicated search results was 147.

2.2. Selection process

Based on the search criteria, 147 papers were identified. A two-step sifting process was then undertaken as seen in Fig. 1. Both sifting stages involved the application of exclusion criteria based on the title and abstract of the identified papers (as recommended in Siddaway, Wood, & Hedges, 2019). At the first stage, exclusion criteria related to the availability of the text, with four search results removed due to the unavailability of both the abstract and full text. A further 27 results were removed for being unrelated to NoD or risk normalization, as defined by Vaughan (1996). Specifically, these studies focused on biological normalization.

Of the remaining 106 search results, a further 40 were removed during the second sift where, based on the title and abstract, papers were excluded if they did not investigate NoD within high-risk industries. This choice of exclusion was due to the present review's focus on investigating safety-related deviations specifically within high-risk industries. While the NoD phenomenon is applicable across other industrial settings (e.g., finance, project management, retail) the motivations and consequences for deviating and risk normalization are likely to differ in the absence of overt physical safety concerns (Banja, 2010). High-risk industries, therefore, present a varied, but somewhat more homogenous, industry focus that more closely reflects the environment of NASA from which NoD originates. For the purposes of the present review, high-risk industries were defined as falling into categories such as transport (e.g., aviation and rail), healthcare, and process industries. As such, papers were excluded from further analysis if either the high-risk industrial setting was not apparent from the abstract, or if both industry and safety were not referenced in a relevant capacity.

At the final selection stage, the full text of the remaining studies was interrogated. Studies for which the full text was inaccessible or unavailable (20), were removed. The full texts of the remaining studies were then analyzed against the criteria from the initial sifts, with the further removal of studies that did not refer to NoD or risk normalization within the text. Four studies were removed due to a lack of clarity on the application of the concept, with insufficient detail available for meaningful analysis. To avoid repetition and maintain focus on the development of the phenomenon since its inception within the aerospace industry, a further four studies were excluded for solely discussing NoD with

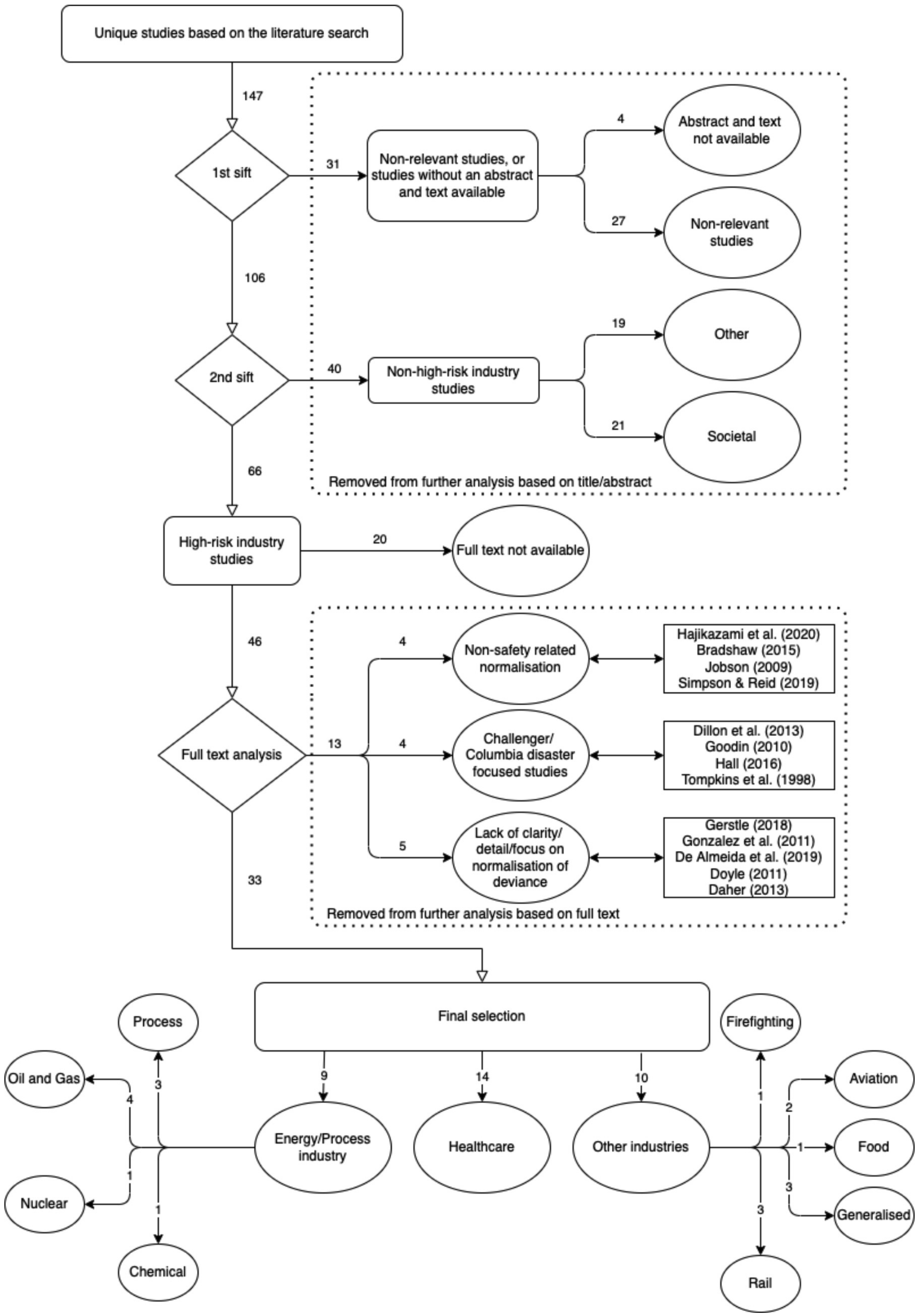

Fig. 1. Literature Selection Process Flow Chart.

reference to the space shuttle disasters. Finally, studies focusing on the normalization of deviance with no focus on safety were also excluded from further analysis.

2.3. Quality assessment

Out of the 33 articles meeting all of the above criteria, 27 were journal articles, 4 were articles from conference proceedings, 1 was a book chapter, and 1 was a master's thesis. Due to the nature of the existing literature on NoD being mostly conceptual in nature, as well as the aim of the present review being to understand the conceptualization of the phenomenon within the academic literature, no specific assessment tool of literature quality was used. These rely on evaluating the empirical integrity of studies based on factors relating to the research's validity and reliability (Siddaway et al., 2019); factors that are not applicable to conceptual papers or case studies. Instead of utilizing a quality assessment tool, presence within the aforementioned scientific databases (Scopus, ProQuest, Web of Science, and Science Direct) was used as a criterion of academic quality and therefore academic literature. Information on the publication and evidence type of each included study is displayed in Table 1.

3. Analysis

To comprehend the complex internal dynamics of high-risk industries, analysis required that the literature be broken down into comprehensive conceptual categories/components. As suggested by Hsieh and Shannon (2005) a directed content analysis approach (a method for summarizing large quantities of text via fewer content categories [Weber, 1990]) was used. This theoretical conceptualization of the phenomenon was used as a guide for the initial identification, coding, and categorization of data, as well as the subsequent development of an initial conceptual framework intended to encapsulate the reported interactions between the identified components.

Given that the majority of the identified literature did not solely focus on the phenomenon of NoD, the coding strategy within the present review required the initial identification of relevant text extracts from within each paper (as suggested in Hsieh & Shannon, 2005). These were identified by reading through the entire text and extracting sections which, directly or implicitly, referenced and/or discussed the NoD phenomenon. Sections were gathered and organized in a Microsoft Word document and were then coded by the first author on the basis of their semantic meaning, relevance, and relationship to NoD. Extract coding and subsequent categorization followed an inductive approach, with each code being generated on the basis of the content of the identified extracts (n = 25). Extracts and initial codes were discussed with the research team to explore the potential higher-order categories (n = 10), which were developed through the amalgamation of semantically/categorically similar codes (Elo & Kyngäs, 2008). Through the process of abstraction (Elo, Kääriäinen, Kanste, Pölkki, Utriainen, & Kyngäs, 2014), these categories were further refined until representative overarching categories encompassing the phenomenon as described and discussed across the identified literature were developed (n = 7). Individual category names were determined by conventional terminology used within the texts (e.g., production pressure, leadership), or were generated using phraseology intended to describe the category's subject matter (e.g., lack of negative consequences). Table 2 presents an overview of the components identified across the included studies. All components were represented across the main industrial sectors; however, some variations in component frequency across industries did emerge. These are discussed in section *4.2 Industry Comparison.*

To encapsulate the identified components from the current review and portray the nature of their interactions as illustrated across the identified literature a conceptual framework was developed (as seen in Fig. 2). The showcased component interactions within the framework were developed inductively through the re-reading of coded excerpts and the identification of reported links and interactivity.

The following excerpt from Arendt and Manton (2015) offers an example of the type of content that informed this identification:

> *"In this case, a senior operating manager put extreme pressure on his staff and workforce to generate production and numerous decisions were evident that put safety behind economics. This resulted in a low sense of vulnerability in operating staff due to the apparent priority of safety behind production. The low sense of vulnerability led to a "superman complex" on the part of some operations staff that encouraged workarounds...*"

The example excerpt portrays the components of leadership, production pressure, and risk normalization, and indicates their interactions. In this instance, the authors report how leadership actions were directly associated with increased production pressure and a low sense of vulnerability (amalgamated into risk normalization), resulting in subsequent workarounds among operating staff (deviances). All of these reported links can be noted within the present framework.

Four of the identified components (production pressure, procedure/environment design, leadership, and culture) displayed a notable number of interactions with one another and were reported to have similarly influential relationships on other elements within the framework, acting as moderating factors. Consequently, while maintained and discussed individually in terms of their features, relevance, and influence on NoD, these were grouped under the broader label of 'Organizational Factors.'

4. Discussion

The aim of the present systematic review was to synthesize the existing literature on the topic of safety-related NoD within high-risk industrial settings. It is made evident throughout the literature that the nature of deviance and NoD is highly complex within industry contexts, wherein a multitude of factors pertaining to organizational, social, and technical processes contribute to the phenomenon (Cavnor, 2018). These are influential to the development and propagation of NoD across its different components. Factors such as production pressure have the potential to influence a range of outcomes, including the likelihood of normalizing risk, the likelihood of deviating from set procedures, and the likelihood of initiating a pre-emptive response following a deviation. Within the present review, we have represented these interactions through the use of an initial conceptual framework which expands upon previous models of NoD by integrating the phenomenon of risk normalization. While these findings are only preliminary, and somewhat limited by the scope and nature of the phenomenon's academic literature, the framework may help in guiding further analysis with primary data sources.

4.1. Conceptual framework

The conceptual NoD framework (Fig. 2) offers a visual representation of the flow path an organization or a group may take from normal operations to the onset of a loss event as illustrated across the identified literature. As within previous models (Hajikazemi, Aaltonen, Ahola, Aarseth, & Andersen, 2020; Heimann, 2005), the present framework illustrates a cyclical progression, where the propagation of NoD is essentially self-sustaining. The cycle is main-

Table 1
Normalisation of Deviance Literature Categorised by Industry Sector and Evidence Type.

Study	Title	Industry Sector	Evidence Type
Arendt and Manton (2015)	Understanding Process Safety Culture Disease Pathologies - How to Prevent, Mitigate and Recover From Safety Culture Accidents	Process Industry*	Conference proceedings - Summary of 3 case studies evaluating process safety culture
Banja (2010)	The Normalization of Deviance in Healthcare Delivery	Healthcare	Journal article - Conceptual article
Bloch and Williams (2004)	Normalize Deviance at Your Peril	Oil and Gas	Journal article - Case study of condenser failure at a major refinery
Bogard et al. (2015)	An Industry's Call to Understand the Contingencies Involved in Process Safety: Normalization of Deviance	Oil and Gas	Journal article - Conceptual article
Cavnor (2018)	Fighting the Fire in Our Own House: How Poor Decisions are Smoldering Within the U.S. Fire Service	Firefighting	Thesis – Policy and incident analysis
Creedy (2011)	Quantitative Risk Assessment: How Realistic are Those Frequency Assumptions?	Process Industry*	Journal article - Conceptual article
Dechy et al. (2018)	Learning Failures as the Ultimate Root Causes of Accidents	Generalised Industries**	Book chapter - Conceptual article
Everson et al. (2020)	Exploring Production Pressure and Normalization of Deviance and Their Relationship to Poor Patient Outcomes	Healthcare	Journal article - Meta-synthesis of 7 qualitative closed claims studies from anesthetise database
Furey and Rixon (2018)	When Abnormal Becomes Normal: How Altered Perceptions Contributed to the Ocean Ranger Oil Rig Disaster	Oil and Gas	Journal article - Case study of the Ocean Ranger disaster
Geisz-Everson et al. (2019)	Cardiovascular Complications in Patients Undergoing Noncardiac Surgery: A Cardiac Closed Claims Thematic Analysis	Healthcare	Journal article - Incident report analysis (34 malpractice claims)
Golinski and Hranchook (2018)	Adverse Events During Cosmetic Surgery: A Thematic Analysis of Closed Claims	Healthcare	Journal article - Incident report analysis (25 incident claims)
Hase and Phin (2015)	The Normalisation of Deviance in the Oil and Gas Industry: The Role of Rig Leadership in Success and Failure	Oil and Gas	Conference proceedings - Conceptual article
Hedgecoe (2014)	A Deviation From Standard Design? Clinical Trials, Research Ethics Committees and the Regulatory Co-construction of Organizational Deviance	Healthcare	Journal article - Case study into a failed UK drug clinical trial
Heimann (2005)	Repeated Failures in the Management of High Risk Technologies	Generalised Industry**	Journal article - Conceptual article
King (2010)	To Err is Human, to Drift is Normalization of Deviance	Healthcare	Journal article - Conceptual article
Mast (2018)	Summary of the King County, Washington, West Point WWTP Flood of 2017	Process Industry*	Conference proceedings - Case study into a major failure at a wastewater treatment plant
McNamara (2011)	The Normalization of Deviance: What are the Perioperative Risks?	Healthcare	Journal article - Conceptual article
Mize (2019)	The Roundabout Way to Disaster: Recognizing and Responding to Normalization of Deviance	Chemical	Journal article – A collection of case studies illustrating NoD within chemical industries
Naweed et al. (2015)	Are You Fit to Continue? Approaching Rail Systems Thinking at the Cusp of Safety and the Apex of Performance	Rail	Journal article - Observation of driving and interviews, focus group interviews, scenario simulation exercise (28 participants)
Naweed and Rose (2015)	It's a Frightful Scenario: A Study of Tram Collisions on a Mixed-Traffic Environment in an Australian Metropolitan Setting	Rail	Journal article - Accident report review, observation, focus group exercise, interview (23 participants)
Odom-Forren (2011)	The Normalization of Deviance: A Threat to Patient Safety	Healthcare	Journal article - Conceptual article
Paletz et al. (2009)	Socializing the Human Factors Analysis and Classification System: Incorporating Social Psychological Phenomena into a Human Factors Error Classification System	Aviation	Journal article - Interviews (28 participants)
Pannick et al. (2017)	Translating Concerns Into action: A detailed Qualitative Evaluation of an Interdisciplinary Intervention on Medical Wards	Healthcare	Journal article - Qualitative evaluation of an intervention (ethnography and 2 focus groups)
Price and Williams (2018)	When Doing Wrong Feels so Right: Normalization of Deviance	Healthcare	Journal article - Conceptual article
Prielipp et al. 2010)	The Normalization of Deviance: Do We (Un)Knowingly Accept Doing the Wrong Thing?	Healthcare	Journal article - Conceptual article
Quinn (2018)	When "SOP" Fails: Disseminating Risk Assessment in Aviation Case Studies and Analysis	Aviation	Journal article - Conceptual article
Ruault et al. (2013)	Sociotechnical Systems Resilience: A Dissonance Engineering Point of View	Rail	Conference proceedings - Case study of a railway accident
Sanne (2012)	Learning From Adverse Events in the Nuclear Power Industry: Organizational Learning, Policy Making and Normalization	Nuclear	Journal article - Conceptual article
Scott et al. (2017)	Countering Cognitive Biases in Minimising Low Value Care	Healthcare	Journal article - Narrative review of PubMed original articles on cognitive biases in clinical decision making
Simmons et al. (2011)	Tubing Misconnections: Normalization of Deviance	Healthcare	Journal article - Review of 116 case studies within 34 reports

(*continued on next page*)

Table 1 (*continued*)

Study	Title	Industry Sector	Evidence Type
Stave and Törner (2007)	Exploring the Organisational Preconditions for Occupational Accidents in Food Industry: A Qualitative Approach	Food Industry	Journal article - Qualitative investigation of 54 accidents, including 24 interviews
Stergiou-Kita et al. (2015)	Danger Zone: Men, Masculinity and Occupational Health and Safety in High Risk Occupations	Generalised Industry**	Journal article - Review of 96 articles
Wilbanks et al. (2018)	Transfer of Care in Perioperative Settings: A Descriptive Qualitative Study	Healthcare	Journal article - Incident report analysis (19 transfer of care claims)

Note. Industry sector represents the papers industrial focus. Evidence type gives information on the paper's publication type, study type, and additional detail where appropriate.
* Industrial sector identified solely as process industry.
** Study either has no specific industrial focus, or the focus is not stated.

tained by the factors and conditions present within a given system, in this instance the high-risk industry context. In the absence of losses or negative consequences, and without adequate preemptive response to near-miss events, deviations and their associated risks become normalized through a feedback loop influenced by prevailing organizational factors (e.g., procedural shortcuts/-corner cutting repeatedly carried out in order to benefit production outputs). In this regard, individual instances of deviations may not be explicitly harmful, rather, it is the cumulative degradation of operating procedure that increases the likelihood of a major loss event.

Each of the identified framework components is defined and explored in relation to the relevant literature. These components should be understood as largely non-linear in their interactions, wherein the degrees of overlap and cumulative contribution is likely to vary depending on the specific industry contexts. For theoretical purposes, it should be assumed that the initial development of NoD within organizations begins when a pattern of deviating from an initial procedural baseline is first sustained.

4.1.1. Risk normalization

Existing literature typically uses the term risk normalization to describe the desensitization to risks present within one's environment, and in broader contexts offers an explanation for how societies come to accept known risks in order to remain operational. Schweitzer and Mix (2018), for example, discuss how risks associated with nuclear energy were largely normalized within French mainstream media in response to the 2011 Fukushima disaster. Public support for nuclear energy was generally unfazed following the incident, which Schweitzer and Mix rationalize to be largely due to the nation's heavy dependence on nuclear energy. Similarly, Luís et al. (2015) observed that increased awareness of coastal hazards appeared to inversely correlate with perceptions of risk regarding the phenomena; an effect that was particularly strong among permanent coastal residents. In this regard, normalization of risk may be largely seen as an adaptive response, facilitating functionality in the presence of circumstances outside one's control (Stave & Törner, 2007). In the industrial context, Stave and Törner refer to several organizational preconditions that aid in normalizing the presence of risk, citing, for example, how operators are often assigned high levels of personal responsibility despite possessing low levels of actual control over their environments and performance of tasks.

A core feature of the present theoretical framework is its integration of risk normalization within the NoD phenomenon, with risk normalization being accounted for as a contributory precursor to the initiation and subsequent acceptance of deviances. Though deviances may occur in the absence of risk normalization, it is unlikely that behaviors will be repeated if their associated risks are continuously perceived to be high. Risk normalization thus requires that individuals develop an increased risk threshold/tolerance wherein they lose the ability to accurately perceive vulnerabilities within their physical or procedural operating systems.

Periods of perceived successes, or at a minimum, periods absent of negative events may further encourage a loss of perceived vulnerability by increasing complacency and overconfidence in the safety of operations and the environment (Hase & Phin, 2015; Mast, 2018). Organizations that maintain a history of success may come to be perceived as "too big to fail" (Hedgecoe, 2014). Arendt and Manton (2015) describe this as a "superman complex," wherein a lack of attention to risk and safety prevents workers from perceiving vulnerabilities within themselves and their environment. Banja (2010) clarifies this illusion of invulnerability by pointing out that inherent system deviations, flaws, and weaknesses are generally inevitable, it is however the unpredictability

Table 2
Distribution of NoD components across the identified literature.

Industry	Sector	Study		Organisational Factors					
			Risk Normalisation	Production Pressure	Procedure/ Environment Design	Leadership	Culture	Lack of Negative Consequences	Pre-emptive Response
Energy/ Process	Chemical	Mize (2019)	X	X	X	X			X
	Nuclear	Sanne (2012)	X					X	X
	Oil and Gas	Bloch and Williams (2004)	X					X	X
		Bogard et al. (2015)		X	X	X	X	X	
		Furey and Rixon (2018)	X	X			X	X	X
		Hase and Phin (2015)	X			X	X		
	Process Industry*	Arendt and Manton (2015)	X	X		X	X		X
		Creedy (2011)	X					X	X
		Mast (2018)	X					X	
Healthcare		Banja (2010)	X	X	X	X	X		X
		Everson et al. (2020)		X		X	X		
		Geisz-Everson et al. (2019)		X					X
		Golinski and Hranchook (2018)		X			X		
		Hedgecoe (2014)	X	X	X		X		X
		King (2010)					X		
		McNamara (2011)		X		X			X
		Odom-Forren (2011)		X		X	X		X
		Pannick et al. (2017)							X
		Price and Williams (2018)		X	X	X	X	X	X
		Prielipp et al. (2010)	X	X	X			X	
		Scott et al. (2017)		X	X				
		Simmons et al. (2011)			X				X
		Wilbanks et al. (2018)		X					
Other	Aviation	Paletz et al. (2009)	X					X	
		Quinn (2018)			X				
	Firefighting	Cavnor (2018)		X	X	X	X		X
	Food Processing	Stave and Törner (2007)	X		X				
	Generalised Industries**	Dechy et al. (2018)		X			X		X
		Heimann (2005)	X	X				X	
		Stergiou-Kita et al. (2015)	X	X			X		X
	Rail	Naweed et al. (2015)	X	X	X				
		Naweed and Rose (2015)		X			X		
		Ruault et al. (2013)			X				

Note. X denotes the component(s) that were identified within each study, and which contributed to the conceptual framework.
* Industrial sector identified solely as process industry.
** Study either has no specific industrial focus, or the focus is not stated.

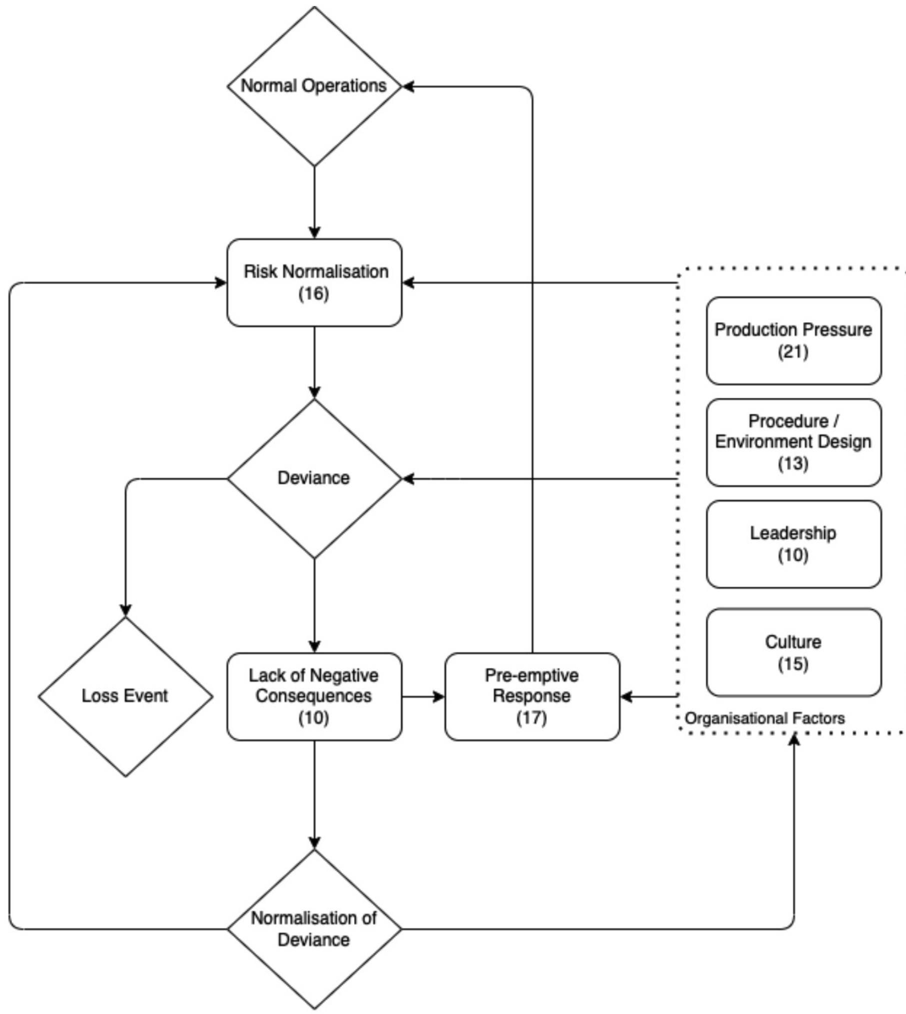

Fig. 2. Conceptual Framework of NoD Based on the Present Systematic Review. *Note.* (n) represents the number of individual studies within which the category was identified.

and infrequency with which these result in serious incidents that encourages complacency.

Under such circumstances, desensitization to hazards can lead to the acceptance of increasing levels of risk. Hase and Phin (2015) describe this process as relatively mundane, innocuous, and largely imperceptible, given the gradual manner in which it develops. Creedy (2011) moreover highlights the temporal nature of the phenomenon in observing how deviations in standard operating procedure often parallel the time elapsed following a past incident. Paletz et al. (2009) similarly outline the dangers of complacency among experienced pilots, who report becoming accustomed to the risks of flying in bad weather conditions, and demonstrate greater engagement in risky behavior than their less experienced counterparts.

An additional variable that has been noted to impact perceptions of risk is the introduction of new protective measures or system safety barriers. These represent the physical and non-physical initiatives used to enhance the safety of operations and mitigate unwanted outcomes. The introduction of a new protective measure generally increases perceived safety, which may unwittingly encourage employee perceptions of system invulnerability (Mize, 2019; Prielipp, Magro, Morell, & Brull, 2010). In other words, new protective measures may be viewed as solutions rather than fail-safes to known problems. Their introduction may therefore incentivize deviations in an attempt to bypass prior safety demands and maximize production efficiency (Banja, 2010; Mize, 2019; Prielipp et al., 2010).

4.1.2. Organizational factors

For the purposes of the present model, several of the identified components are encapsulated under the category of organizational factors; specifically, the components of production pressure, procedure/environment design, leadership, and culture. These components, and their relevance within the organizational context, were often discussed in tandem, and as interconnected facets which are influential on one another. From the organizational standpoint, it is the accumulation of these organizational components that contributes to the normalization of risk, propagation of deviance, and failure to respond adequately to early warning signs (i.e., pre-emptive response).

4.1.2.1. Production pressure. Broadly speaking, production pressure refers to both overt and covert organizational demands and emphasis on output efficiency (Everson et al., 2020). Issues with production pressure typically arise due to conflicts between the demands of safety and production. This conflict is complex and well documented within the realm of high-risk industries where production pressure is commonly discussed as a key contributory factor in industry accidents (Goh, Love, Brown, & Spickett, 2012; Mohammadi & Tavakolan, 2019; Probst & Graso, 2013).

The consensus across the high-risk industry safety literature is that.

production pressure and safety are akin to antagonist agents, whereby increased attention to one often causes detriment to the other (Cavnor, 2018). This idea has been discussed further by Heimann (2005) with reference to type I and type II errors. In principle, high-risk industries are generally cited as being averse to committing Type I errors (active errors of commission), where implementing an incorrect policy or course of action results in failure. Heimann (2005) notes that Type I error aversion is indeed often present initially within organizations, which typically begin operating with low thresholds of risk tolerance so as to create the impression of a functionally safe system. Under such conditions, accidents are generally infrequent and less severe, which encourages focus to shift towards the elimination of Type II errors of omission (e.g., the use of unnecessary measures that are costly to efficiency and productivity). This desire for increased productivity and efficiency acts as the driving force for deviations and shortcuts to be undertaken by operators (Dechy et al., 2018).

In the absence of immediate negative outcomes, organizations and individuals may become susceptible to the aforementioned influence of risk normalization and may feel justified in re-evaluating and altering their potentially costly and overly 'conservative' thresholds. As a result, a so-called "cycle of failure" is propagated, wherein continued deviation from initial standards in pursuit of efficiency ultimately culminates in major failure (Heimann, 2005).

Naweed, Rainbird, and Dance (2015) and Naweed and Rose (2015) reference how organizations within the rail industry emphasize punctuality and 'on-time performance,' describing the heightened pressure experienced by operators running behind schedule as a condition under which they report greater susceptibility to taking shortcuts and violating procedures to recover lost time. Specifically, Naweed et al. (2015) note that driver interpretation of signals has shifted over time in order to facilitate faster train movement. This behavior has increased the likelihood of 'signal passed at danger' (SPAD) events, wherein a train passes a stop signal without explicit allowance to do so; a practice which, when performed frequently, is associated with an increased risk of derailment or collision.

Pressures associated with having to accomplish more with less are exemplified in a number of other cases throughout the literature, such as Mize (2019) who outlines a case of operators within a chemical plant violating standard procedure to meet increasing production targets, and Cavnor (2018) who notes evidence of firefighters skipping safety checks prior to entering compromised structures to achieve tactical goals more efficiently. Within healthcare, McNamara (2011) and Arendt and Manton (2015) cite managerial and institutional pressures on productivity and maintenance of the operating room on schedule as factors typically accountable for the introduction of deviations. Clinicians may, for example, disconnect vitality monitors prior to the end of a procedure, or before a patient has fully emerged from anesthesia, in order to speed up the turnover process (Prielipp et al., 2010). However, Bogard et al. (2015) state that these shortcuts and deviations rarely result in serious process safety issues and often directly facilitate the organization's target progression.

It is important to also acknowledge, however, that the relationships between production pressures, safety, and Type I and II errors vary across individual industries. Specifically, it is somewhat more complicated in occupations such as healthcare and firefighting where circumstances may cause production pressures to be explicitly tied to physical safety. In these contexts, both Type I and Type II errors may result in harm or loss of life, either through the initiation of incorrect/unsafe treatment, or the withholding of correct treatment (Price & Williams, 2018). In this regard, motivations for deviating may differ in some respects from traditional process industries given that production demands are directly concerned with minimizing the harm done. Insights from clinician reports regarding their rationale for procedural deviations reflect this, with individuals often citing a desire to minimize patient discomfort and eliminate unnecessary or counterproductive measures as being justification for procedural deviations (Banja, 2010; Scott, Soon, Elshaug, & Lindner, 2017).

Deviations guided by a patient-centric or 'greater good' approach may provide justification for the normalization of shortcuts, given the perception that these might offer a means of attending to more patients, or provide the opportunity to prioritize those with more serious conditions (Price & Williams, 2018). Cavnor (2018) similarly notes a form of 'melioration bias' (a tendency towards alternatives seen as preferable in the short-term) in regard to certain operating procedures; namely the correct wearing of PPE, which firefighters have claimed hinders movement and impedes life-saving action.

Among process industries, common generalized instances of justified deviance may be observed in shortcuts performed by operators seeking to improve productivity; not for explicit and immediate personal gain, but rather as a means of satisfying broader organizational demands (Mize, 2019). These deviations, intended to maximize productivity, may be further compounded by a pre-existing rule ambiguity and unfamiliarity, particularly for tasks that do not involve standardized checklists (Banja, 2010; Mize, 2019; Stergiou-Kita et al., 2015).

4.1.2.2. Procedure/Environment Design. Within many high-risk industries, special considerations must be made for the design of both the physical work environment and the nature of processes and procedures in order to facilitate productivity and reduce risk (Gambatese & Hinze, 1999; Marsden & Green, 1996; Park & Jung, 2003; Reuter & Camba, 2017). These considerations may include placing emphasis on computerization and automation to streamline processes and reduce workload (Marsden & Green, 1996; Park & Jung, 2003; Wang & Ruxton, 1997), standardizing operating procedures (Kurt, Arslan, Comrie, Khalid, & Turan, 2016), and evaluating and making provisions for fail-safes that will mitigate unintentional error or sudden failure (Garrick & Morey, 2015).

Procedures are agreed-upon methods of work, intended to ensure that tasks are performed in an efficient, controlled, and safe manner (Marsden & Green, 1996). Issues with procedures generally arise when these are deficient in designating activities or enabling the successful accomplishment of tasks (i.e., due to being inaccurate, outdated, incomplete, or overly complex and demanding; Park & Jung, 2003).

Throughout the identified literature, inappropriate implementation of procedures and poor environmental designs were frequently cited as contributory to the initiation and maintenance of deviant behavior. The reasoning provided was that under time and production constraints, procedural or environmental limitations often provide justification for deviances and violations (Mize, 2019; Price & Williams, 2018); with some operators arguing that perfect compliance to rules and standards makes it impossible to achieve productivity demands (Banja, 2010).

Price and Williams (2018) state that the very presence of deviance inherently signals potential flaws within a system's environment or work process. In reference to healthcare, they illustrate how factors such as inconveniently placed hand hygiene stations decrease hygiene compliance, and even minor obstacles such as malfunctioning barcode scanners disrupt entire workflows and prompt the skipping of the scanning process in order to achieve on-time administration of medication.

In some organizations, Quinn (2018) argues that rather than amending poor procedure and environmental design, deviances become a normalized and expected practice intended to "fill in the gaps" of standard operating procedures. In other instances, there may be an initial lack of overt procedural rules or adequate resources that precipitates compensatory individual and team solutions (Cavnor, 2018; Hedgecoe, 2014; Stave & Törner, 2007).

A further weakness explicitly referenced within the literature is that of maladaptive alarm/warning system design resulting in the experience of alarm fatigue. Bogard et al. (2015) highlight how overexposure to alarms causes desensitization and loss of vulnerability towards these. Frequent alarm exposure, particularly when false, normalizes the alarm presence as routine, prompting a lack of response. Poor implementation of an alarm system may also encourage procedural deviations intended to circumvent system activation, as evidenced in the railway industry where cautionary signals have been largely devalued by drivers. Naweed et al. (2015) report that on some journeys it is routine to operate in a continuous "alarmed" state without ever being clear of cautionary signals.

4.1.2.3. Leadership. Within organizational contexts, leadership describes a variety of multifaceted management roles that encompass a range of responsibilities, styles, and behaviors depending on the context and the leader's respective level of responsibility (Denis, Langley, & Rouleau, 2010; Pilbeam, Doherty, Davidson, & Denyer, 2016). Senior management and leadership are responsible for a range of decision-making directly associated with safety, including training and resource allocation and investment, oversight, scheduling, and maintenance of equipment (Kelloway, Nielsen, & Dimoff, 2017; Reason, 2000), as well as role modeling and influencing worker attitudes and behavior (Flin & Yule, 2004; Pilbeam et al., 2016).

Reason (2000) has been particularly critical of the role of leadership, identifying decision makers and line management as a core element of any productive system. Reason further argues that many organizational accidents can be traced back to deficiencies in managerial decision-making. Similarly, within the identified literature, Everson et al. (2020) describe the nature of an organization's safety culture to be largely determined by the approaches taken by executive leadership. Mize (2019) notes that it is the leadership of an organization that is responsible for setting expectations for employee attitudes and behavior, with the responsibility of providing sufficient training and reinforcement of operational discipline. In this regard, leadership failures in the maintenance of a system's risk mitigation often play a crucial role in facilitating NoD (Bogard et al., 2015). Actions by leadership are generally perceived as having top-down consequences, wherein poor leadership decisions are filtered through the various levels of an organization, causing damage to an organization's operational safety and general safety culture (Hase & Phin, 2015).

Supervisors may, for example, avoid or choose not to discipline operators who engage in shortcuts and deviations in order to simplify processes, reduce workloads and increase production speed (Bogard et al., 2015). To conserve resources, some organizations may also fail to provide adequate training by limiting the amount of time available for operators to familiarize themselves with new tools or procedures (Geisz-Everson, Jordan, Nicely, & McElhone, 2019), or in some cases, through the active teaching of already normalized shortcuts and deviations (Banja, 2010; Odom-Forren, 2011). A key issue here is that in such instances deviations performed by authority figures typically go unchallenged (McNamara, 2011).

Actions such as these facilitate NoD by instilling a "production over safety mindset" when led by the example of decision-making authority figures (Cavnor, 2018). When an organization places excessive demand on economics, leadership may fail to uphold process safety as a core value, resulting in the dismissal of warning signs and the encouragement of workarounds in the interest of production (Arendt & Manton, 2015; Dechy et al., 2018). Younger, and more inexperienced employees are particularly vulnerable to production demands given their limitations in power, agency, and inability to accurately comprehend or question safety procedures (Banja, 2010; Stergiou-Kita et al., 2015). Furthermore, it is suggested that observations of issues and weaknesses may be minimized when reported to supervisors/higher authorities due to a fear of repercussion or punitive action from leadership and/or a general lack of confidence that voicing concerns would lead to actual change (Banja, 2010; Furey & Rixon, 2018; Odom-Forren, 2011).

4.1.2.4. Culture. Culture describes the collective nature of an organization's underlying values, beliefs, expectations, and perceptions that guide and inform individual and group behaviors and practices (Everson et al., 2020; Van den Berg & Wilderom, 2004). Van den Berg and Wilderom (2004) describe organizational culture as the "glue" which binds together an organization. When it comes to NoD, the significance of culture is pertinent with regard to understanding how formal and informal attitudes and decision-making processes enable deviances to take place and be normalized. As previously mentioned, within Vaughan's investigation, understanding the culture within NASA as a social organization was crucial to helping identify the rationale and motivations, particularly from a managerial standpoint, behind the decision-making that took place prior to the disaster. Vaughan specifically outlined how NASA's culture was one with a "major preoccupation" with bureaucracy, which failed to realistically account for safety, cost, efficiency, and productivity demands (Vaughan, 1996).

Throughout the identified literature, organizations were cited as possessing individual identities that shaped the nature of group dynamics within work settings (Cavnor, 2018; Price & Williams, 2018; Stergiou-Kita et al., 2015). These social identities, while influenced by organizational demands, were said to also exist independently as products of an organization's history, projected image, and working environment. Cavnor (2018) for example, extensively discusses the cultural and social implications of firefighting, describing how beliefs shared among firefighter groups often encourage behaviors that favor risk acceptance. As a result, authors frequently identified the importance of understanding culture as a variable that may inadvertently sustain unhelpful practices (Everson et al., 2020; Hase & Phin, 2015; Price & Williams, 2018; Stergiou-Kita et al., 2015).

An organization's history, externally projected image, and working environment, were said to be of particular significance to culture, as these often become integrated with the individual identities of work personnel, fostering traditions and operational practices that may be both adaptive and maladaptive (Cavnor, 2018; Stergiou-Kita et al., 2015). Price and Williams (2018), note how healthcare workers traditionally promote a standard of individual perfection that ultimately distracts from addressing wider underlying issues relating to equipment, systems, or procedure. Similarly, the distinct social image of firefighters may promote mutual trust, courage, and concern for the safety of others, however, it may also encourage excessive and unreasonable risk-taking (Cavnor, 2018; Stergiou-Kita et al., 2015). In this regard, Hedgecoe (2014) notes that the everyday culture of work groups may often inadvertently accommodate and normalize risk; leading organizational cultures to foster environments where normalized deviances are mundane occurrences rather than exceptions (Hase & Phin, 2015). Stave and Törner (2007) similarly describe the working practices of a team as the product of continuous internal negotiations, which may lead to risk acceptance within work cultures that do not prioritize safety.

Alternatively, some organizations were said to also manifest a 'silo effect,' characterized by a lack of cohesion and interaction between workgroups and departments. These experience fragmented individual group cultures, operating on independent standards so as to meet their own needs rather than a common shared agenda across the organization (Golinski & Hranchook, 2018). This may result in inconsistent practices across an organization, wherein a lack of communication perpetuates rule unfamiliarity and deviations in practice. Thus, despite the aforementioned potential for unwanted consequences, a shared social identity among employees is typically seen as desirable within the organizational context (Golinski & Hranchook, 2018).

Helmreich and Merritt (2001) described how organizational culture represents a 'complex framework' composed of national, organizational, and professional attitudes and values. It should therefore be noted that while frequently referenced, given its breadth and complexity, the concept of organizational culture is not always clearly defined. This has also been pointed out within wider literature where the notion of organizational culture has been criticized for lacking clarity and definition (Van den Berg & Wilderom, 2004). Moreover, there is debate as to whether an organization may truly be defined under a singular overarching cultural identity, or whether its culture should be understood as the product of several collective subcultures and group identities across various departments and chains of command (Willcoxson & Millett, 2000). The present review does distinguish the component of culture as somewhat independent of leadership and production pressure, which may traditionally be considered subsets of the organizational culture. While, as with all the themes discussed, there is likely to be overlap in the actual manifestation of components within real-world settings, culture as it pertains to NoD was in many instances flagged as a unique contributor to the phenomenon, particularly with regards to the organizational culture surrounding safety (Arendt & Manton, 2015; Cavnor, 2018; Everson et al., 2020; Stergiou-Kita et al., 2015).

4.1.3. Lack of negative consequences

In general literature, the relevance of perceived negative consequences has been explored primarily within the realms of human risk perception, specifically with regard to the human evaluations and management of risk on individual and societal levels (Creyer, Ross, & Evers, 2003; Johnson & Tversky, 1984; Sitkin & Pablo, 1992). The perceived lack of negative consequence works in tandem with the previously discussed issue of unnoticed, latent errors/failures that accumulate over lengths of time (Dekker & Pruchnicki, 2014). Similarly, Rasmussen (1997) highlights the issue of reliability being mistaken as an indicator of safety (i.e., that something is good enough simply by virtue of its past successes). As with risk normalization, the absence of consequence fosters a 'presumption of safety' that impairs the collective and individual abilities to detect risk (Hedgecoe, 2014).

Unsurprisingly, the absence of negative consequences is consistently cited as an integral element of NoD and is discussed extensively in relation to deviance and risk perception desensitization (Price & Williams, 2018). It is widely understood that perceptions of risk and risky behavior are subjective and may be positively or negatively evaluated depending on the framing and evaluative points of reference used (Kahneman & Tversky, 1979; Tversky & Kahneman, 1985). With regards to NoD, when a deviation fails to result in an apparent adverse outcome, it may be seen as an indication that initial standards or procedures are over-conservative (Creedy, 2011). This perception, or framing, justifies deviations as acceptable evolutions of the productive process, wherein behavior is merely adapting to maximize efficiency; a notion that is parallel and complimentary to Rasmussen's "migration model" of the adaptive processes undertaken by organizations attempting to maximize productivity and profitability. Rasmussen notes that this behavior is typical of sociotechnical systems given the pressures and constraints under which they operate (Rasmussen, 1997). These pressures encourage deviations in attitude and action, which in the absence of consequence, are highly prone to repetition (Paletz et al., 2009), and acceptance by both workers and management throughout the organization (Bogard et al., 2015); with perceived benefits to production additionally de-incentivizing intervention and enforcement of discipline (Bogard et al., 2015).

4.1.4. Pre-Emptive Response

Perrow (1999) famously argued that "normal accidents" or failures within highly complex systems, such as those found within high-risk industries, are likely to be unavoidable given the complexity of the system's components (machinery/equipment, operators/employees, procedures etc.) and the manifold possibilities for these components to interact and result in failure. Turner and Pidgeon (1997), however, denotes that incidents are nearly always preceded by warning signs and claims that major accidents require preconditions to be present, often for extended periods of time. Turner argues that accidents can be prevented if these are identified and appropriately dealt with. Reason (1990) describes these preconditions as "resident pathogens," that is, latent failures which may combine with any number of factors such as active failures (human error and violations) or system faults to produce an adverse outcome. Reason, in agreement with Perrow, states that highly complex systems do contain a greater number of resident pathogens, and will thus be more susceptible to failure; however, he also asserts that these can be monitored, assessed, and understood with adequate system knowledge (Reason, 1990).

Pre-emptive responses to risks have in more recent years been discussed in terms related to organizational resilience (i.e., the ability of an organization to identify, cope with, and learn from incidents and failures and adjust positively under challenging conditions; Hutter, 2010; Vogus & Sutcliffe, 2007). A well-known general approach for pre-emptively dealing with hazards within high-risk work environments involves the implementation of a hierarchy of controls framework, intended to identify and prioritize hazards and their respective intervention strategies (Barnett, 2020; Hopkins, 2006; Morris & Cannady, 2019). Depending on the hazards present, a range of control measures with various levels of efficacy can be implemented. These typically include elimination (physical removal of a hazard), substitution (replacement of a hazard with a less dangerous alternative), engineering controls (isolating a hazard from workers, often through technology), administrative controls (changes in work practices) and use of PPE (use of personal protective equipment; Morris & Cannady, 2019).

With regards to NoD pre-emptive response refers to measures taken to anticipate, identify, and prevent the propagation of maladaptive deviance. This encompasses both the nature of proactive measures used to detect and respond to near-misses/signals, as well as the quality of retroactive learning following an incident or near-miss (Cavnor, 2018). The importance of identification and learning is particularly relevant given that pre- and post- investigation processes are both susceptible to normalization biases. Initial signals normalized in advance of an incident may be subject to the same framing after an accident, often in an attempt to cover up wrong-doings and minimize responsibility (Furey & Rixon, 2018; Sanne, 2012). Moreover, signals of potential disaster can manifest at various time intervals and across varied locations, which may cause individuals within an organization to view pre- and post-events from a detached personal level (Simmons, Symes, Guenter, & Graves, 2011).

Ideally, behavioral deviances, warning signals, and near-misses should always be accounted for. However, in light of the potential associated effort and costs, individuals may be biased towards discounting originally proposed risks when there is a lack of incentive for reporting/speaking up (Banja, 2010; Cavnor, 2018; Sanne, 2012). Furthermore, while some organizations outline policies regarding what events need to be reported, criteria are often subjective and dependent upon voluntary input (Dechy et al., 2018).

Another component detrimental to pre-emptive learning is that of inappropriate safety reporting systems. Pannick et al. (2017) describe a healthcare setting wherein the formal mechanism for recording incidents was an online reporting system that was difficult to use and poorly suited for this purpose, with long delays in the processing of even relatively simple issues; resulting in common/recurrent problems being left unreported and normalized within everyday practice. Failure to document warning signs or procedural changes, even those perceived as positive workarounds and innovations, enables these to remain unchallenged, and set precedents for procedural ambiguity and shifting norms (Mize, 2019). When incident analysis does take place, Price and Williams (2018) specifically outline the importance of appropriate system/process investigation in order to avoid simply blaming individual behaviors or components. They cite how patient safety literature demonstrates the efficacy of addressing issues from a system, rather than a human, perspective.

4.2. Industry comparison

While the healthcare industry represents the largest single industrial sector among the identified literature, many of the core components and patterns of NoD appear generally consistent across the industries accounted for within this review. Production pressure was among the most consistently referenced and discussed components across the industry literature, however, its prevalence in healthcare (11/14 healthcare papers) is particularly noteworthy. Another distinction between healthcare and other industries can be seen in the apparent lack of reference to risk normalization within the identified healthcare literature (3/14 healthcare papers, by contrast to 8/9 papers within the process industry and 5/10 within other industries).

These differences may be due to a number of reasons however a comparative analysis of healthcare to other high-risk industries by Gaba (2000) extensively discusses several key structural differences between healthcare and other high-risk industries; including a lack of centralization, regulation, investigation, and reporting by contrast to other high-risk industries such as aviation, oil and gas, nuclear, and chemical manufacturing (Gaba, 2000; Hudson, 2003). While issues of production demands may be more openly vocalized, issues surrounding the conscious or unconscious normalization of risky behaviors or malpractice may be more covert within healthcare, potentially due to the more explicit medical attitudes regarding individual responsibility and blame (Gaba, 2000; Hudson, 2003; Price & Williams, 2018). Gaba also describes how healthcare systems may often enable "structural secrecy," wherein problems can be "defensively encapsulated" within respective units or departments and blame may be shifted elsewhere.

Depending on the industry, the nature of risk and risk management will also vary, given the variations in potential outcomes associated with hazards and risky behavior, and whether these are likely to only affect workers themselves or have consequences for others (Banja, 2010; Cavnor, 2018; Hudson, 2003). In this regard, healthcare, while conscious of medical dangers, may be said to have a more reactive focus to managing dangers, with some proactive considerations; given that medical personnel manage a wide range of unpredictable dangers and hazards experienced by others but rarely themselves. Other high-risk industries, such as oil and gas and nuclear, may be described as having more proactive approaches, given that their workers must, by contrast, contend with an array of potential risks that have the potential to be hazardous to themselves, their colleagues, and the wider society (Hudson, 2003).

Furthermore, as previously highlighted, the production outcomes and demands for service industries, particularly public service industries such as healthcare and firefighting, by comparison to process industries, should be accounted for; specifically with regard to understanding the nature of industry outputs (i.e., minimizing harm and saving lives vs. maximizing physical productivity and efficiency). This difference is not undermined within the present model, as 'production pressure' does not specify the type of motivation it describes, but rather refers to any form of medium or motivation by which perceived output demands are prioritized and likely to encourage deviations in practice. Arguably, these descriptive differences may also fundamentally be merely a simple case of categorization and semantics; however, given the complexity of organizational contexts and individual experiences, the importance of understanding and accounting for the unique variables within individual organizations should not be understated.

4.3. Theoretical contribution

The current academic literature on the topic of NoD indicates that research has been largely independent and fragmented across a variety of sectors. The present systematic review synthesizes literature from a variety of high-risk industries in an attempt to ascertain common components of the phenomenon and introduce a new conceptual framework that seeks to encapsulate the manner in which the phenomenon has been presented and discussed. One of the main theoretical contributions of the present paper is the integration of risk normalization within a model of NoD as an integral component in the development and maintenance of the phenomenon. While entirely conceptual at present, this model suggests that intervention methods for the prevention of harmful NoD may need to focus on the initial normalization of risk; more specifically, ensuring that operator perceptions of risk do not degrade over time. Furthermore, the present review highlights the impact of organizational factors on the propagation of NoD. While these are likely to be context-specific and variable, they point toward factors that should be considered when investigating NoD within the high-risk industry context (e.g., Is production pressure encouraging deviations and short-cuts? Does culture within the work environment discourage the reporting of near misses?).

4.4. Limitations

While the present review and conceptual model are based on the current academic literature on the topic of NoD, there are some notable limitations that should be considered. Namely, the model is preliminary and untested and based on a relatively small sample of academic literature. While a systematic method of analysis was utilized for its creation, with directed content analysis often being used to develop conceptual models (Elo et al., 2014), an inherent level of subjectivity and potential bias exist both in the initial coding and subsequent categorization and model mapping. This may have been particularly pronounced within the present review where only one coder was used (first author). However, the coder remained open to new and alternative codes or potential categorizations. Future research will address this limitation through the testing of the preliminary framework in real-world settings (e.g., case studies).

A further consideration that should be addressed is that NoD with regards to the high-risk industry has so far been mostly discussed within the confines of conceptual articles or on the basis of accident reports and case studies. Of the 33 identified studies within the present review, 21 utilized secondary data, and of the remaining 13, seven were based on case studies. As such, the majority of the reviewed literature consisted of studies that did not present novel data or findings, but rather built upon and discussed the relevant topics from a number of industry perspectives. Though these offer valuable insights and points of consideration, the presence of primary data within this review has been severely limited. The review is therefore confined to focusing on the phenomenon from a largely conceptual and observational standpoint. The lack of applied research on the topic is an issue highlighted by several authors, who acknowledge that many of the observations and speculations, though theoretically reasonable, are yet to be actively quantified in terms of real-world intervention and risk reduction (Arendt & Manton, 2015; Bogard et al., 2015; Cavnor, 2018; Creedy, 2011).

4.5. Future research

These limitations suggest testing of the present model is required prior to any serious or consequential application. Specifically, the framework should be tested and quantified with respect to real-life settings, individual industries, and primary data, in order to make further refinements and provide validity. This could be accomplished through the analysis of incident reports, or by using primary data obtained from interviews or direct observations. Additionally, applied methods of analysis could be used in order to test specific components of the framework.

Of specific interest would be investigations into the development of risk normalization at the individual level, the specific factors accelerating this normalization, and the examination of potential interventions intended to reduce the likelihood that normalization of risk will lead to the initiation and normalization of deviance. Furthermore, the effect of the absence of negative consequences following a deviation could be investigated, with specific reference to the subsequent likelihood of engaging in said deviation. As suggested by Bogard et al. (2015), behavioral research is desperately needed to support the mostly conceptual nature of the academic literature investigating the present phenomenon. Based on the present review, we argue that more general empirical and experimental research would not only aid in the understanding of NoD but may further provide insights into potential interventions through the investigation of the aforementioned causal relationships. The use of an experimental vignette method (EVM) in particular could lend itself to further investigations, wherein fictitious scenarios may be manipulated to investigate the impact of specific factors on the attitudes and perceptions of participants (Aguinis & Bradley, 2014). These scenarios can be designed to replicate the working environments of individual workforces, allowing for the assessment of specific predispositions to normalization of risk/deviance. Such investigation may also be of particular importance for investigating elements of risk normalization within healthcare settings where the concept has thus far not been explored or considered in as much depth as in other high-risk industries.

Additionally, the further conceptualization of the role of Type I and II errors in the development of NoD within organizational systems appears warranted, especially with respect to their efficiency, safety, and cost/benefit interactions/trade-offs, as highlighted by Heimann (2005); in addition to their potentially varied presentations and implications within different industrial sectors (e.g., healthcare versus process industries). Understanding the priorities of an industry and its workers with regards to type I and II errors may also be supplemental to NoD investigations by illuminating where an organization stands from a "cycles of failure" perspective (Heimann, 2005). The identification of patterns of deviance in tandem with type I and II prioritization may prove to be particularly important in the recognition of otherwise overlooked system risks and may help inform on appropriate preventive measures and/or beneficial system changes.

5. Conclusion

The study of NoD is theoretically based on the systems approach to accident causation, wherein emphasis is placed on understanding how dynamic components of a system enable a given phenomenon to manifest and propagate. An important facet of this approach is its emphasis on understanding the impact of latent failures, framing active failures as by-products of a flawed system rather than vice-versa. The benefit of this perspective is that it enables the development of interventions and improvements that can be applicable and generalized across a range of contexts that accommodate similar system dynamics. The present review, which aimed to synthesize the existing literature on the phenomenon of NoD from a range of high-risk industrial sectors, may represent an initial step toward such interventions with regard to the NoD phenomenon and high-risk industry. Using a directed content analysis approach, the present systematic review of 33 articles synthesizes the existing literature and presents its findings within a conceptual framework. The framework seeks to encapsulate the reported interactions between identified industry components and NoD, while building upon prior examples through the incorporation of risk normalization. While unable to offer specific interventions, the present paper provides foundations for future applied research on the topic and offers a common framework for the phenomenon that is applicable across a range of industrial sectors.

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