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The Road to Olympic Failure is Paved in Poor Risk Management

Abstract

In recent years there have been numerous high-profile incidents in professional cycling that have endangered the lives of cyclists, fellow competitors, and spectators in track and road disciplines. Yet, there has been little research conducted to ascertain why, and how things can be improved within the sport to improve safety. To illuminate this area, we apply safety culture theory to the now infamous Australian Cycling 2021 Olympic incident that saw their Olympians handlebar snap clean off during the competition. The results show that dimensions of safety culture are apparent in this incident, with distinct parallels between it and high-profile failures in other industries. The lack of adherence to rules, the existence of light-touch international regulation, and management safety attitudes are concerning, and suggestive of a need for immediate improvement at a governing level. This research provides a conceptual basis for further research in the area to ensure interventions are effective at preventing future safety critical incidents within the sport.

Keywords: Safety Culture, Cycling, Risk Management, Accident Analysis, Olympics, UCI, IOC.

Introduction

“I don't know how many freak accidents become a normal accident. I dread to think if it had been worse. It should be a proactive decision to try and make it safer before it's a terrible accident.”

Matt Bostock (2022)

The pressure of elite sports competitiveness can inspire athletes, and their teams, to “win at all costs” leading them to neglect processes and standards along the way (Chen, et al., 2019; Volkwein-Caplan & Verlag, 2013). This drive and desire to succeed in elite sport has cast a negative light on safety controls, perceiving safety measures as a means of compromising performance – a measure of sporting productivity. This philosophy can be compounded by a failure to pro-actively assess risk by sports organisers and official federations, leading to potentially dangerous work environments. A view shared by Isle of Man Track Cyclist Matt Bostock in the quote above, who was involved in a crash at the 2022 Commonwealth games which saw several riders leave the track at high velocity and enter the crowd, injuring several spectators and themselves. Unfortunately, this wasn't the first-time track cyclists had gone ‘over the top’ yet track cycling governing bodies had not intervened after previous incidents to ensure the risk of it reoccurring had been mitigated. Other sports, such as F1 have recognised the risk posed to audiences from similar scenarios and have repeatedly adapted their circuits which include additional ‘catch fences’ protecting drivers and spectators if a car leaves the track and goes ‘over the top’ (FIA, 2022).

F1 is no stranger to safety incidents, however it is adept at learning from them, implementing safety standards for drivers without jeopardising performance (Brooks, 2020). For example, the Grand Prix Drivers' Association (GPDA) was founded in 1961 as a forum for drivers to discuss safety matters and the future direction of the sport independently from race organisers (Allen, 2017). All current F1 drivers are signed up to the GPDA, with its chairman, former driver Alex Wurz and director, current driver Sebastian Vettel (Kalinauckas & Kew, 2022; Allen, 2017). On December 16th, 2015, the GPDA requested that the FIA, the sports international governing body, provide better head protection for drivers because of numerous incidents, culminating in the tragic death of Henry Surtees in the years previous.

Though initially criticised by many (including drivers), the Halo that was developed by the FIA to offer this protection in 2018 and has since been praised as ‘one of sport's greatest innovations’ (Crebolder, 2020). A three-part safety feature on F1 cars, the Halo was designed to act as a barrier between the driver and any debris that may be hurtling in their direction (FIA, 2017; Crebolder, 2020). There were

various reasons as to why the Halo was so unpopular, it was considered unsightly, took away the thrill of fully open cockpit racing, and drivers had concerns regarding visibility (Crebolder, 2020). It wasn't until Fernando Alonso's McLaren landed on top of Charles Leclerc's Sauber, rebounding off the Halo, that drivers realised why the system was implemented at the start of the year (FIA, 2018; Andrei, 2022). Fortunately, no injury occurred to either driver, and F1 went on to reach a global audience amassing 490 million that year, with a cumulative audience of 1.55 billion viewers three years later (Statista, 2022).

There are numerous differences between F1 and competitive road cycling, making the former easier to predict and control. A comparison of F1's longest closed circuit (7km) and the 298km road route of Milan-San Remo allows for better prediction, and thus safety measures, of potential crash sites in F1 (Laverick, 2020). However, when it comes to competitive track cycling the average circuit is only 250m, with only 2 banked corners for consideration – suggestive that an 'over the top' event could've, and should've, been assessed and mitigated. The work of Salmon et al (2017), more recently adapted by Hulme et al (2021, p26) studied performance optimisation in elite women's road racing and concluded that *"the peloton and convoy form a complex, highly dynamic system including both human agents (e.g., domestiques, directeur sportif, commissaire) and non-human factors (e.g., environment, bikes, vehicles, communication devices, computers) that exhibit non-linear interactions, multiple control and feedback loops, loose and tight coupling, rapid decision making, and emergent properties and outcome)"*. These characteristics are apparent in some shape or form within the industrial safety literature when viewed through various theoretical lens such as Normal Accident Theory (Perrow, 1984, Shrivastava et al., 2009, Tamuz and Harrison, 2006), High Reliability Theory (Weick, 1987; O'Neil and Kriz, 2013; Sutcliffe, 2011, Roberts and Rousseau, 1989), and more recent systemic risk assessment methods such as Systems-Theoretic Process Analysis (STPA) (Leveson, 2011)¹. When considered in relation to the Rasmussen (1997) Risk Management Framework, Hulme et al, (2021) identified risk (albeit from a position of performance optimisation) at various levels that included equipment and technology, nutrition, race planning, tactics and strategy, specific features of the terrain and topography, rider behaviours, opposing team behaviours, and race management and governance.

All these sports accept that crashes are, to an extent, inevitable when racing, however F1's safety regulations are much more apparent (Laverick, 2020). This, along with other racing incidents has led some within the professional cycling community to question how seriously safety is being taken by all involved. After seven Grand Tour winner, Chris Froome's 2018 near fatal crash, British cycling coach,

¹ For the interested reader an in-depth analysis of various risks, agents, barriers, and hazards within professional cycling using different analysis techniques including STPA is conducted by Hulme et al (2021).

Sir David Brailsford mused “*Formula One has moved forward in the last 10 or 15 years - why shouldn't cycling?*” (Drayton, 2019; Laverick, 2020).

The Management Committee of the Union Cycliste Internationale (UCI), the international governing body of all competitive cycling, reinforces rider safety, and state that they are committed to sustainable development within the sport (UCI, 2021a). To this end Olympic track cycling can be considered to have an element of ‘top-down’ causation when it comes to rider safety, as properties at the higher levels (e.g. prescriptive rules and regulations) directly influence activities at those found beneath (e.g. choice of equipment, rider position) (Ladyman et al, 2013; Sturmberg, 2018). In terms of medals won per event contested, cycling is one of Australia’s most successful Olympic sports, third only to swimming and athletics respectively (AOC, 2022; Olympic Database, 2022). Australian Cycling (AusCycling), the national governing body that represents cycling competes across five disciplines – Track, BMX Racing, BMX Freestyle, Mountain, and Road (AOC, 2022). The Covid-19 pandemic brought about uncertainty in the lead up to Tokyo 2020 Olympics for all countries, with athletes’ ability to practice, the safety of training, quarantine regulations, and the cancellation or postponing of sporting events all interrupting preparation (Csulak, et al., 2021). The International Olympic Committee (IOC) made the decision to postpone the Games to 2021, giving athletes and their nations an extra (fifth) year to prepare (Yanagawa, 2022). In the case of AusCycling, the pandemic had resulted in decreased production and shortened testing timeframes for their track bikes, but the one-year delay had allowed for apparent “adequate time for ‘in-use’ training” (AusCycling, 2022).

This article will investigate the risk management failures within the elite sport of track cycling, through the application of safety culture theory in a work environment in which track cyclists race around a 250m 45-degree banked wall velodrome, reaching speeds greater than 72km per hour (AOC, 2022). Specifically, we investigate the failure of the custom-built base plate of Australia’s Olympic cyclist, Alex Porter’s pursuit bike that failed during a qualifying heat at the Tokyo Olympics on 2nd August 2021, causing him to crash head-first into the track floor at 65 km/h (AOC, 2022). Subsequent to this crash, AusCycling launched an independent investigation into the crash that culminated in the publicly available AusCycling (2022) incident report.

Safety culture refers to the individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation’s health and safety management (HSE, 1998; Cooper, 2000; Leaver & Reader, 2016a,b) and is a sub-facet of organisational culture (Cooper, 2000; Blockley, et al., 1989). Although different approaches exist to theorise and measure organisational culture (Cameron & Quinn, 2011; HSE, 1998), to understand how any industry balances the competing demands of productivity and safety, safety culture is the dominant theory (Leaver & Reader, 2019; HSE, 1998; Glendon & Stanton, 2000; Hopkins,

2006; Nordöf, et al., 2015). It explains how beliefs and practices are directly influenced by the social environment, and how issues within an organisation's safety culture often underlie mishaps within other high-risk domains such as aviation, construction, healthcare, nuclear power, oil and gas exploration, and financial trading (Bento et al. 2021; Cooper 2000; Fang & Wu 2013; Guldenmund 2000; Mearns et al. 2013; Pidgeon 1998; Reiman and Oedewald 2007; Leaver and Reader, 2019). Elite sports, particularly those in which human and machine are pitted against the clock are without question, safety critical industries, mishaps can be detrimental to both a sporting organisation; governing body, and to an individual sportsperson (Chen, et al., 2019). Previous research has indicated that the cause of mishaps often relates to the poor risk management and ineffective procedures within other industries, as well as in professional sports (Chen, et al., 2019; Leaver & Reader, 2016a,b; HSE, 1998; Hulme et al, 2019; Hulme et al, 2020).

Within this article, the authors will examine whether safety culture provides a sound theoretical framework for the explanation of the failures within the organisational culture and risk management of AusCycling, resulting in the crash at the Tokyo Olympics. This will be achieved through detailed analysis of the independently investigated AusCycling (2022) incident report. The purpose of this article is to determine whether the safety culture of AusCycling can provide a cogent explanation for why the failure occurred. This will be achieved by drawing on surrounding literature as a method of outlining any potential future steps for research and intervention for both national and international cycling federations.

The Olympics, Cycling Technology and Safety Culture

As the largest worldwide multi-sport event, the Tokyo Olympic Games reached a global broadcast exceeding three billion across linear television and digital platforms (IOC, 2021). Cycling has remained a prevalent family of sports within the Games since the inaugural Olympic Games of the modern era, with track cycling attracting 73% of interest from British citizens in the 2020 Games, coming third to athletics and swimming events (Ibbetson, 2021). Unsurprisingly, there is an innate desire by the audience, and sporting federations whose future funding is reliant on results, for records to be broken and medals won. The obvious route to this success would be through human performance improvements, achieved through better coaching; intensive, specific training, and early identification of talent. A less obvious, but complementary route is through the implementation and use of innovative technologies and engineering.

As a relatively complex piece of engineering, the design of track bicycles has dramatically changed since the 1948 Games. The addition of lightweight materials such as carbon fibre have allowed the bicycles to become faster, whilst moulded grips, drop sprint handlebars, aero helmets, skinsuits along

with the use of wind tunnels and computer simulations have allowed for improved aerodynamics and drag reduction (Robinson, 2020; Fitzgerald et al, 2019). Aerodynamic drag accounts for 90% of the resistive forces a cyclist must overcome whilst at racing speed (Neptune, et al., 2009). Consequently, cycling technology has focused extensively on reducing aerodynamic drag to increase speed (Neptune, et al., 2009). Innovations in the aerodynamics of cycling have sparked debate as to whether records are reflective of cyclists' skill and ability or whether they are solely based upon engineering design (Neptune, et al., 2009). Refinements to structural and functional equipment as outlined above, alongside nonconventional riding positions can reduce aerodynamic drag and increase speed by up to 40% (Neptune, et al., 2009). However, as has been pointed out by 4-time Olympic gold medal winning track cyclist Laura Trott, the increase in speed comes with it an increase in risk *"I think the crashes are getting worse and it's because the speeds are getting higher, the positions are getting more extreme,"* (Ingle, 2022).

Handlebars play an incredibly important role in cycling performance, both on the road and in the velodrome, forming a major part of the 'cockpit' for the cyclist. They aide the overall position of the cyclist, ensuring they remain as aerodynamic as possible (Conceição, et al., 2022), whilst providing a key contact point for body weight and balance on the bike, with speed and direction controlled from them. The wider the handlebar, the greater the frontal surface area of the cyclist, which has negative impact on aerodynamics (Conceição, et al., 2022). This causes greater disturbance to air flow, forcing the air to separate from the object's surface, increasing air pressure drag and giving a 'parachute' effect, where the rider is being pulled backwards. By reducing the width of the handlebars, drag is reduced, thus allowing the cyclist to travel at a greater speed when applying the same amount of force whilst pedalling (Conceição, et al., 2022).

Handlebar failures in elite cycling competitions, whilst rare, are not uncommon as can be seen from Table 1 below. The 2012 Tour de France Champion, Sir Bradley Wiggins' chances of winning were ruined in the Tour of California in 2016 after facing major engineering and mechanical faults with his road bike (Terrell, 2016). Further, Australia's Rohan Dennis' mid-race handlebar mishap left him in fifth after what was promised to be a medal-worthy race at the Olympic time trial race (Lane, 2016). The failures experienced by both cyclists were put down to the amount of force applied to the carbon handlebars by the athlete whilst riding along uneven roads, causing a crack in the handlebar extension, resulting in the handlebar snapping clean off (Terrell, 2016; Lane, 2016). Within all failures, the cycle frames, specifically the handlebars would have all been tested against ISO 4210-5: 2014: Safety requirements for bicycles – Part 5: Steering test methods (ISO, 2015). This particular standard, ISO 4210: 2014 replaced ISO 4210: 1996, and is technically revised every five years, as per standard regulation (ISO, 2014). It is of note that ISO 4210-5 is currently under development and set to replace the 2014 standard (ISO, 2023).

Table 1: List of recent cock pit failures in elite cycling*

Bike Part	Rider/Recall	Competition/Product
Steerer Tube Failure	Stefano Viezzi,	Warm-up Junior World CX Championship 2023
Handlebar Failure	Recall	Salsa Cowhipper, Cowbell, Cutthroat, Warbird 2023
Handlebar failure	Alex Porter	Tokyo Olympics Men's Cycling Track 2021
Handlebar failure	Mathieu van der Poel	Le Samyn Road 2021
Steerer Tube failure	Tom Van Asbroeck	Omloop Het Nieuwsblad Road 2021
Handlebar failure	Maxime Roger	Tour de Moselle Road 2017
Handlebar failure	Recall	Aeria Ultimate carbon aerobars 2017
Handlebar failure	Rohan Dennis	Rio Olympic Men's Cycling Road TT 2016
Handlebar failure	Bradley Wiggins	Tour of California Road TT 2016
Handlebar failure	Recall	Aerobars Bicycle Handlebars 2015
Handlebar failure	Recall	Cervelo p5 bicycle 2014
Handlebar stem failure	Recall	Specialised Shiv Aerobar 2013
Handlebar failure	Recall	Shimano Pro Vibe drop handlebars 2012

**This list is not exhaustive*

The UCI is the guarantor of the proper application of ethical and sporting regulations, albeit they outsource their standard and regulatory testing. For equipment that is subject to a UCI approval procedure, allowing it to be used within competition, it must first be approved with certification of ISO 4210 compliance known as the “norm” (UCI, 2021b). These international standards are applicable to all bicycles; city and trekking, young adult, hybrid, mountain, and racing (ISO, 2014). The multitude of failures at the elite level of competitive racing as outlined above in Table 1.0 therefore raises the question as to whether these generic international standards are designed for the intensity and forces exerted in elite professional cycling (Holzel et al, 2011). Other professional sports have their own prescriptive safety testing and regulatory regimes over and above generic standards, as part of their approach to safety management within their competitions. For example, the US National Football League (NFL) conducts extensive laboratory research to evaluate which helmets best reduce head impact severity, prohibiting those that perform poorly in their league even if they can be legally sold to the public. The Federation Internationale Automobile (FIA) also impose strict static and dynamic crash tests that must be passed before F1 vehicles can race on a circuit, reflecting the nature and forces imposed on a driver should a crash occur. Similarly, the Federation International Ski (FIS) requires downhill helmet standards to meet the EN 1077 test procedure but at a higher test speed of 6.8m/s, prior to 2013 this was 5.4 m/s. Albeit the work of Steenstrup et al (2018) has indicated that even at this increased speed test the FIS standards still fall below impact velocities in real head injury situations.

Complex systems can vary in type, size and scale, from the micro, to meso, and macroscopic levels (Simon, 1996; Ottino, 2003; Galea, Riddle, & Kaplan, 2010; Ladyman et al, 2013; Hulme et al., 2019; Hulme et al, 2020). Australian Olympic track cycling is no different and can be considered to exist within a socio-technical system, that demonstrates interconnectedness and complexity in social and technical systems (Kleiner et al., 2015; Leveson, 2012; Hulme et al, 2020.; Ylonen et al, 2022). The

work of Hulme et al (2020) is beneficial in considering sport as a complex socio-technical system, with Salmon and Mclean (2019) considering a micro, meso, and macro ‘supersystem’ in the context of soccer. In the current context this includes multidimensional interactions between different subsystems as well as multilevel interactions pointing to the individual (e.g., rider, mechanic, coach, team manager) ‘micro’ level, an organisation (e.g. AusCycling) at the ‘meso’ level, and an organisation’s external environment (Ylonen et al, 2022) at the ‘macro’ level. For example, the external environment in which AusCycling finds itself includes interactions that are regulatory at national and international ‘macro’ levels (e.g., UCI & Australian Olympic Committee) (Hulme et al., 2017), technological (e.g. availability of aerodynamic and bio-mechanically optimised equipment) (McIntosh, 2012; Hulme et al., 2017), and economic (e.g., Sport Australia (performance based Australian government funding) and commercial sponsorship (Green, 2007; Kavetsos & Szymanski, 2009), creating pressures to which AusCycling needs to respond and adapt to survive, which in this context means winning medals (Harvey and Stanton, 2014).

What appears to the layperson on tv as someone riding a simple machine (bike) around a controlled environment (track) to personal Olympic victory, is complicated by high levels of expertise in a variety of fields that includes sports science, aerodynamics, and operational excellence. As such, winning an Olympic gold medal is much more complex, with multiple underlying interdependencies that are invisible to the naked eye, therefore winning is never guaranteed, even with an impressive track record of success (Glouberman & Zimmerman, 2002; Hulme et al, 2020).

Safety Culture

The combination of attitudes, values and perceptions influential to the way risk and safety are managed make up the overall safety culture of an organisation (Leaver & Reader, 2019; Le Coze, 2019). Organisations with a positive safety culture are characterised by explicit and tacit communication styles in relation to risk; the ability to learn from incidents, shared perceptions of the importance of risk and by employee confidence in incident reporting systems and the efficiency of preventative measures (HSE, 2021). In a socio-technical system such as professional cycling as outlined above, safety culture is considered an important means of accident prevention (Shen et al, 2015; Yang et al, 2023). The concept of safety culture is one which became more prevalent after being identified as a recurring causal factor across a variety of catastrophic accidents (e.g. Deepwater Horizon, Chernobyl, Fukushima etc. (Nöggerath, et al., 2011; Berglund, 2020)². Across these catastrophes, poor risk practices at an operational level were shown to be influenced by cultural norms that were determined by organisational

² The authors acknowledge that regardless of safety culture, different industrial domains, and their respective organisations, possess unique complexities and interactions within their systems. As such when comparing incidents from these domains to the current AusCycling incident throughout the remainder of the article these idiosyncrasies should also be considered.

and industry characteristics (Leaver & Reader, 2019). These observations were significant factors in the realisation of operational error as the core contributing factor to organisational accidents - drawing the focus away from individual employees, and towards the systems and environments in which they operate (Leaver & Reader, 2019; Reason, et al., 2011). This includes how risk failures reflect the normative tendencies, perceived priorities (Production versus Safety), and robustness of systems and procedures for managing risk (Guldenmund, 2000; Dekker, 2012).

Safety culture is a concept which is valuable both theoretically and practically. Theoretically, safety culture provides guidance to organisations in the understanding of risk management and how the occupational environment can shape and determine the ethical and risk-related behaviours of employees (Leaver & Reader, 2019). It also enables organisations to actively monitor their culture and determine whether the occupational environment that influences attitudes and behaviours is favourable or not (Leaver & Reader, 2019). There are five over-arching dimensions used to measure the safety culture of an organisation as identified and elaborated on by Leaver & Reader (2019), these include Management Commitment to Safety; Risk; Rules and Regulations; Systems; and, Collaboration. These dimensions provide explanatory insight into what behaviours are deemed risky and are outlined in Table 2 below.

Table 2: Recognised Components of Safety Culture

1) Management Commitment to Safety: Policies with regard to supervision and motivation of the workforce and the adherence to the rules (e.g. perceptions of staff for the managerial expectations on risk-related behaviours) Blame and Culpability -A measure of the culture of blame shifting or lack of acceptance of organisational responsibilities (Shelly, et al., 2006) Employee Participation (e.g., perceived empowerment) – The extent to which employees perceive they are able to contribute to decisions and organisational process (Wiegmann, et al., 2004) Management Safety Attitude – Management perceived prioritisation of safety and productivity <i>Example:</i> (Håvold, 2010) Supervisor/Management Expectations – The perceived expectations of management to perform safely (Olsen, 2010) Safety Motivation – The confidence, enthusiasm and discipline of the team at a specific time Shared Belief in Importance of Safety – The beliefs and values in regard to safety that originate from manager-directed joint learning (Reader & O'Connor, 2014)
2) Risk Management: Policies with regard to which, when and how risks are evaluated (e.g. responding to error, risk-taking behaviours) Appreciations or risk (e.g., risk-taking behaviour – The perceived likelihood and action or inaction taken as a result of gaining or losing asset value <i>Example:</i> (Cox & Cheyne, 2000) Confidence in safety (e.g., control measures, safety standards) – The state of being certain with the management’s course of action in regard to safety process and procedure <i>Example:</i> (Lee & Harrison, 2000) Conflict between work and safety – Impacts the decision to meet performance requirements (productivity) or to adhere to the standard operating procedure (safety)
3) Rules and Regulations: Policies with regard to formal procedures and instructions (balanced by what is trained and how workers are recruited and selected). Basically, policies determining the structure of work (e.g. safety protocols) Checklists – The existence of formalised documentation for task completion and recording Planning – The existence of procedures to evaluate risks and establish the necessary safety measures for avoiding accidents Rule Dissemination – The availability (e.g., access) and distribution of information in regard to safety rules within and across the organisation <i>Example:</i> (Farrington-Darby, et al., 2005) Safety Rules (e.g., the complexity of instructions) – Refers to the existence of protocols and procedures for operating safely during routine and non-routine tasks <i>Example:</i> (Flin, et al., 2000) Safety training and drills – The existence of training programs or opportunities to simulate situations where employees face routine and non-routine tasks <i>Example:</i> (Lu & Yang, 2011)
4) Systems: Policies with regard to how identified risks are avoided, reduced or controlled by design or layout (e.g. policies determining the choice of barriers that control present dangers and risks) and policies with regard to maintenance and inspection (e.g. policies, incident reporting) and how often, etc.) Incident reporting (non-punitive) – A method of recording details of non-routine events that occur within the organisation that can undermine organisational safety and performance (e.g., human error, Systems error) <i>Example:</i> (Filho, et al., 2010)

Internal audits – The provisions of independent assurance that Risk Management, governance and internal control processes are operating effectively
Organisation of system access rights (e.g., access to information based on roles) – Segregation of access to system information and modifications based on job responsibilities
Resources – The efficient apportioning of time, capital and personnel
Systems alerts and controls – The capability of the system to accurately monitor and detect system abuse
Systems maintenance (e.g., breach reports sent consistently) – The timely maintenance and modification of system controls and capabilities

5) Collaboration/Organisational Communication: Policies with regard to effective collaboration and interaction of (groups) of people (e.g. communication, teamwork on safety)

Ability to speak up within the organisation – Refers to extent to which employees are comfortable or perceived to be able (e.g., organisational constraints) to voice concerns inter-/intra-team *Example:* (Ek, et al., 2003)

Transitions and Teamwork Across Units – Refers to the coordination of processes and tasks within and between interdisciplinary teams *Example:* (Halligan & Zecevic, 2011)

Trust in Colleagues – The measure of confidence and competence in team members

Conflict between work and safety (e.g., risk appetite and performance goals) – Risk appetite impacts the decision to meet performance goals whilst simultaneously adhering to the necessary risk practices. *Example:* (Clarke, 1999)

Source: *Leaver & Reader, 2019 and authors own analysis*

The philosophy of safe production is one in which all workers are able to identify that neither safety nor productivity work well without the other, knowing that an organisation must survive and prosper, but to do safely (Stewart, 2020). The promotion of a positive safety culture relies on senior management implementing health and safety regulations and procedures within an organisations core business objectives, ensuring employees share a common belief that safety should be prioritised in all situations (HSE, 2005). The UK Health and Safety Executive (HSE) published a report identifying how productivity can remain high whilst upholding a positive safety culture. They identified five key aspects along with organisational transparency, that when applied in contingency, maximise productivity whilst adhering to all health and safety measures and organisational objectives (HSE, 2005). This has been elaborated on by researchers such as Dekker (2012) who indicate that if organisations penalise employees for making mistakes or slowing down productivity, they are less likely to report safety problems or near misses. This ‘safety voice’ of employees is the act of speaking up about safety to prevent physical harm, and can be considered as similar to ‘employee voice’ described as “*a verbal behaviour in which people communicate a concern to others (e.g., colleagues) to change a perceived situation, with a similar propensity (i.e., discrete, constructive, proactive)*” (Noort et al , 2019, p 117). A case in point being the safety gagging of sub-contracted oil rig workers, and subsequent threats to their job security should they report issues, on the Deepwater Horizon platform prior to its explosion (Reader and O’Connor, 2014).

Interestingly, this ability to ensure employees felt empowered to stop work should they feel unsafe, regardless of the productivity consequences was a key component of the safety culture of the London 2012 Olympics construction project which was considered the ‘safest yet’ (Glass, 2013). To put this in context, the commitment to providing a ‘positive’ safety culture meant that 62 million man-hours were worked with an accident frequency rate (AFR) of 0.17 (calculated per 100,000 hours worked) by June 2011, the industry average at the time was 0.4. The more recent work of Pandit et al (2019) who investigated hazard recognition and perception in 57 different construction workplaces across the

United States, has shown that this is enhanced in organisations with a more positive safety climate. Research carried out prior to the London Olympics identified the good practices contributed to the overall safety culture, defined as “the way we do things around here” (Sugden, et al., (2011). The UK Health and Safety Laboratory (HSL) were able to assess safety culture by speaking to personnel at all levels within the multi-billion-dollar project (Latitude, 2013). The HSL report identified a large part of the success was in making safety and risk a personal issue, including examples of stopping work in response to a serious incident, allowing employees time to reflect on how similar incidents could be avoided in the future (Latitude, 2013; HSL, 2012). The London Olympics created a safety culture structure which enabled and rewarded good practice (Finneran, et al., 2012; Sugden, et al., 2011). In contrast, the Building and Wood Workers’ International (BWI) union published a report, criticising the Tokyo City Government and the Japanese Sport Council, who are behind structures such as the national stadium and Olympic Village (ISHN, 2019). BWI reported that labourers were overworked and discouraged from reporting poor employment conditions (BWI, 2019). The report highlights safety culture failures including the dismissal of a complaint which had been filed in response to an injury due to poor levels of lighting (BWI, 2019). Since the 1960’s, the cost of the Olympic Games has exceeded its forecasted budget, at an average of 172% in inflation-adjusted terms (Sorkin & Kessler, 2021; Flyvbjerg, et al., 2020). Researchers at Oxford University concluded that the Tokyo Games were the ‘highest overrun on record for any type of megaproject’ (Flyvbjerg, et al., 2020), having forecasted a spend of \$7.3bn, but a 2019 Government audit put the actual spend at \$28bn (Sorkin & Kessler, 2021). Ultimately, as a long-term mega project with global reach, culminating in the largest public sporting event in a given year, safety culture extends to all areas of the Olympic Games. From the construction of the parks and stadiums to the manufacturing of sports equipment, protection of audiences, and the training of elite athletes.

The Current Study

In summary, safety culture theory may provide a useful framework and conceptual understanding for the explanation of how poor risk management at AusCycling, resulted in the equipment failure that led to Alex Porter crashing at the Tokyo Olympics. To do so, we systematically analyse the official evidence provided in the AusCycling (2022) report: “An Investigation into the Handlebar Failure that Occurred in the Australian Men’s Team Pursuit race at the Tokyo 2020 Olympics” using a safety culture perspective, allowing us to:

1. Determine whether safety culture theory can account for equipment failure during competitive cycling events
2. Test the utility of the Leaver and Reader (2019) Safety Cultural dimensions framework and whether and how they influenced risk practices as reported in the AusCycling (2022) report.

Methodology

The methodology adopted to analyse the evidence contained within the AusCycling (2022) report was qualitative content analysis. The AusCycling (2022) report into the event contained expert witness testimony from management, engineers, designers, mechanics, coaches and athlete riders to inform the investigation of the incident. Athlete performance data was also used to investigate the critical loading forces against which the design and manufacture of the bike components could be compared. This allowed for in-competition safety loading factors to be calculated. Further, a third-party supplier facilitated the specialist testing of bike parts and drafted engineering analysis and calculations, which were then validated by the Lead Investigator of the report. This testing was completed under the purview of the reports Lead Investigator whilst bike components were brought to the testing facility when required and removed when the tests were complete. Further the report was compiled by a qualified air accident investigator working independently from the AusCycling governance and athlete performance structures. The investigation method used to compile the report was based on the same techniques used by the Australian Transport Safety Bureau (ATSB) for aircraft accidents. As such the technical qualifications, evidence gathered, and past experience of the report's author would provide fertile evidence in which to determine whether safety culture theory can account for equipment failure in this current context. Studies that employed this method to evaluate risk disclosures are compatible with this form of evidentiary content analysis. (Owusu-Sekyere, et al., 2022; González, et al., 2021; Tuggle, 1996; Ring et al, 2016). The content analysis carried out within this article follows a similar method presented by previous research in the area (Leaver and Reader, 2019; Leaver and Reader, 2016a,b; Kowal and O'Connell, 2014; Reader and O'Connor, 2014).

Initially the report was independently read by both researchers to ascertain whether further exploratory investigation would be deemed worthwhile. After corroboration between researchers that there was merit in further exploratory research, the AusCycling (2022) report was loaded into qualitative data analysis software, NVivo. The report was first analysed by Researcher 1 who has expertise across risk management in a variety of high risk and complex industries, and Researcher 2 verified the coding (who has expertise in risk management). The method of analysis used was derived from the five dimensions (and 24 sub-dimensions) of safety culture identified by Leaver and Reader (2019), outlined in the literature review (Table 1). The parts of the report that were associated with a (sub)dimension of safety culture were coded within NVivo by Researcher 1, and then verified ex-post by Researcher 2. In the context of validity and reliability, qualitative data analysis can introduce bias, as results are achieved through personal interpretation of data. However, the use of software in qualitative data analysis has been found to add rigour to research (Welsh, 2002). NVivo minimises error, and by coding specific dimensions of interests, NVivo can yield more reliable results rapidly through the removal of human error (Roberts & Priest, 2006; Richards & Richards, 1991). As is to be expected in any qualitative analysis, there was some divergence in opinion between Researcher 1 and Researcher 2 during the code

verification process, this was rectified by finding consensus between researchers, as is standard in data-driven thematic methodological protocols (Braun and Clarke, 2006; Clarke, Braun, and Hayfield; 2015). It is also worth acknowledging that Researcher 1 races road and TT bikes competitively, albeit at an amateur level, and whilst not particularly successful in this endeavour, they have an excellent working knowledge of bike maintenance (assembly/disassembly) and parts which would also assist in this analysis.

To investigate the role of safety culture in relation to AusCycling's handlebar failure, the following analyses were performed:

1. Establishing the role of safety culture in the AusCycling (2022) report

To determine whether safety culture theory could account for the handlebar failure, the authors investigated the extent to which the safety culture dimensions as listed in Table 2, could describe the underlying problems leading to failures in risk management. This allowed the researchers to build a dataset of textual information that was classified according to the safety culture dimensions.

2. Developing an initial framework of cultural dimensions for measuring and evaluating the safety culture of AusCycling

As evidenced in Table 2, and the results in Table 3 below, this article has refined the initial framework of sub- and cultural dimensions of Leaver and Reader (2019) in relation to professional cycling environments. This was achieved through an examination of the most commonly occurring dimensions as identified within the AusCycling (2022) report. Simply, where safety culture (sub)dimensions were identified within the report, these were included within the framework, where they were absent, the dimensions were removed. This article then examined the utility of the specific safety culture dimensions for explaining AusCycling's risk practices. This was achieved by identifying segments of text within the report previously coded as being associated with a dimension of safety culture. These segments were then analysed to establish whether and how the specific activities identified as problematic within AusCycling (2022) report were influenced by the cultural dimension. Associations between the risk practices and failures of AusCycling were identified and examined against the pre-determined Leaver and Reader (2019) safety culture dimensions.

Results

The qualitative content analysis of the AusCycling (2022) report yielded rich data on how the organisational environment of AusCycling influenced attitudes and behaviours, leading to the handlebar failure. To contextualise the incident, examples of the safety culture (sub) dimension failures as outlined in the AusCycling (2022) report are included in Table 3 overleaf. It illustrates that 35.35% of the failures experienced due to safety culture, related to the dimension of '*Rules and Regulations*', and, within this dimension, the most coded sub-dimension was '*Planning*' (32.65%). The least frequently identified

safety culture dimension was '*Management Commitment to Safety*' (10.00%). In terms of sub-dimensions of safety culture, the most frequently identified were '*Planning*' and '*Transitions and Teamwork Across Units*' (13 cases each in the report). The sub-dimensions Organisation of System Access Rights (Systems) and Systems Maintenance (Systems) were not identified within AusCycling (2022) report, albeit the domain specific nature of this incident may preclude these when compared to other industries such as financial services in the Leaver and Reader (2019) research.

Table 3.0 Safety Culture (Sub) Dimensions Identified in the Report

Dimension (% as a proportion of all dimensions)	Sub-Dimensions (% as a proportion of all sub-dimensions within a dimension)	Example From Report
Management Commitment to Safety (10) (10%)	Blame and Culpability (1) (10%)	
	Employee Participation (3) (30%)	“at interview he was aware of the extended Base Bar requirement but was offered no opportunity to participate at the time.
	Management Safety Attitude (4) (40%)	“In discussions between the Australian Cycling Team and Bastion Advanced Engineering, the ISO 4210-5:2014 durability or fatigue requirement of 200,000 cycles was reduced by the Australian Cycling Teams Performance System Manager to 50,000 cycles”
	Safety Motivation (2) (20%)	“Most telling was his statement “I have tried to forget [my experience]”
Risk (15) (15.15%)	Appreciations of risk (5) (27.78%)	“In use, the additive manufactured Titanium Base Bar was exposed to riding and training forces some one-and-one half times the Australian Cycling Team Specified design and test forces.”
	Confidence in safety (2) (13.33%)	“Fatigue testing Specified was reduced by the Australian Cycling Team from 200,000 to 50,000 cycles.”
	Conflict between work and safety (8) (53.33%)	“This laissez-faire attitude appeared to have spread across a range of equipment acquisition, maintenance and support activities.”
	Checklists (7) (20%)	“A comprehensive Bicycle Build Book was drafted but when issued, only partially covered the technical aspects.”
Rules and Regulation (35) (35.35%)	Planning (13) (37.14%)	“The Specification for the design was inadequate and based only on a Computer Aided Design skin drawing modified to include a 35mm extension. Specifically, the Base Bar to steering fork mating surface was not required to be machined, nor was a tolerance stated.”
	Rule Dissemination (4) (11.43%)	“there were scant policies or processes in a technical sense”
	Safety Rules (7) (20%)	“individuals made it up as they went along”
	Safety training and drills (4) (11.43%)	“The reduction in controlled fatigue testing was an opportunity lost to probe the Specification for accuracy”
Systems (16) (16.16%)	Incident reporting (non-punitive) (1) (6.25%)	“At interview, this non-conformance was raised as a Bastion deficiency when the situation had been explained to and accepted by the Australian Cycling Team. There was no record of the Australian Cycling Teams acceptance of the non-conformance.”
	Internal audits (4) (25%)	“No Handlebar Service Schedule Reports for any CA-06 Base Bars were found”
	Resources (9) (56.25%)	“Further time pressure related to the need to have finished parts in time for UCI presentation by November 2019 and the desire to get practice on the bike in the correct position”
	Systems alerts and controls (2) (11.11%)	“this acceptance testing was never completed.”
Organisational Communication (23) (23.23%)	Ability to speak up within the organisation (1) (4.35%)	“This graduate engineer highlighted the ‘closed shop’ environment to implement improved procedures as a major frustration”
	Transitions and Teamwork Across Units (13) (56.52%)	“The Australian Cycling Teams Project Numbers spreadsheet listed 41 of the 50 projects having ‘Requirements’ all being conveyed “verbally”
	Trust in Colleagues (7) (30.43%)	“Those interviewed were professional and at the various levels, competent, but the absence of process and compliance was striking”
	Conflict between work and safety (2) (8.70%)	“The base material is some four times stronger than steel with the Achilles Heel of having a poor fracture toughness which is also known as fatigue performance.”

Source: AusCycling (2022) - Authors own calculations

Informed by the findings within AusCycling (2022) report as outlined in Table 3, this article reports on the identified associations between AusCycling's safety culture and risk practices. This article further interprets these associations within the wider literature, surrounding safety culture, industrial risk management, and elite sporting risk management. Crucially, interpretation allows for the safety culture dimensions to be mapped alongside the observed/reported behaviours, thus, confirming a relationship between the AusCycling's safety culture and the ultimate handlebar failure.

Management Commitment to Safety

Management commitment to safety can be manifested in the positive attitudes toward the activities relating to safety management and in the behaviours visible to employees. Within the AusCycling (2022) report, behaviours and attitudes of senior management and supervisors were identified as key drivers of risk practices, in response to safe operation prioritisation. For example, the Australian Cycling Team Performance Systems Manager reduced the number of required cycles from 200,000 to 50,000; indicating the durability of the bikes would be proven by "in-service riding". Going further, this same manager was cautioned as to the use of titanium material as opposed to carbon fibre, in respect of fatigue damage (AusCycling, 2022). This raises the question as to whether the number of tested cycles was dramatically reduced by the Performance Systems Manager, as they were aware of the increased chance of fatigue damage and/or production delay consequences as a result.

Throughout the AusCycling (2022) report, there was clear evidence of insufficient scrutiny by management, tasked with overseeing the various stages of production. A consistent pattern emerges of a lack of prioritisation of safety by management, as enacted by the employment of unqualified and inexperienced personnel. This was further exacerbated by the non-existence of a documented process that would have provided an abundance of missed opportunities to identify the impending handlebar failure before it became catastrophic. The surrounding literature on safety culture, and more specifically, management commitment to safety, indicate whilst less tangible than other dimensions of safety culture, the behaviours, attitude, and style of leadership are considered to have an equal effect on the overall safety motivation and culture of an organisation (Singh & Verma, 2018). An organisation's commitment to safety is considered a requirement for employees to adopt safe behaviour (Rahlin, et al., 2022), and their consistent methods of handling practices highly valued by employees (Suhanyiova, et al., 2021).

Within the boundaries of elite sport, management commitment to safety regarding organisational issues have been consistently identified as a significant factor in achieving sporting and even Olympic success (Arnold, et al., 2015). It is those at management levels who retain the greatest responsibility and accountability for the overall success, performance, and safety of employees and athletes at all levels

(Arnold, et al., 2015). Their role is to lead and manage the attainment of the organisation's goals through their own individual behaviours and attitudes (Arnold, et al., 2015; Rekoso, 2020). Poorly made decisions to cut costs, save time and meet performance standards without appreciation of associated consequences on system safety are more likely to result in failure, as was the case of AusCycling and many other high risk industry disasters (Flin, et al, 2000).

Risk Management

The description, perception and acceptance of what potential risks and dangers to an organisation are at both the operations and boardroom level, are essential to an effective safety culture (Olive, et al, 2006). When viewed through the lens of safety culture the onus is on the risk management policies that envelope the tools and techniques to measure and assess risk e.g. policies relating to the ability to stop production, inspection, cross checking, and escalation of incidents/near misses (Leaver and Reader, 2019). The ability to determine which risks are necessary to avoid, and which risks can be taken to achieve optimum performance, determines an organisation's risk appetite and the policies to be wrapped around them. As a result of conflict between work and safety, many shortcuts were taken: the designated timeframe to design and make the cycle frame was reduced from ten to four months, even with additional geometric changes to the cockpit being requested with a 35mm extension of the base bar was requested to obviate a human to base bar conflict (AusCycling, 2022). Whilst this geometric alteration relieved the issue of rider Alex Porter having a physical distance conflict, structurally, the extension and flare of the handlebar wings changed the stiffness and overall fatigue performance (AusCycling, 2022).

The reduced fatigue performance however was not picked up, due to the fatigue testing being reduced to one quarter of the specified 200,000 cycles (AusCycling, 2022). Hence, when the base bar was subject to forces one and a half times greater than specified (as per the testing outlined within the report), the frame snapped – a clear underappreciation of risk that is indicative of a weak risk culture (Cox & Cheyne, 2000). A safety versus productivity pattern, and a distinct lack of clear policy and procedure can be observed within the AusCycling (2022) report. Similar to AusCycling, Kvalheim and Dahl (2016) have shown over a 7-year period, work pressure was the greatest impediment to safety compliance as a function of safety culture in the Norwegian oil and gas industry. With the statement that “*costs may be gauged in race time saved versus race time to win*” it was clear that safety was an afterthought when compared to performance, even when safety may not have diminished the ‘*race time to win*’. The lack of adherence to standards and specifications, and by decreasing design and testing timeframes, AusCycling increased their risk of equipment failure in an environment in which policies around risk management were scant.

With regards to risk as a dimension of safety culture, the surrounding literature is consistent with the above, with research showing how poor internal risk management processes and a lack of relevant risk data as a result of employee inability to escalate incidents and concerns undermine the development of robust risk management models (Bryce, et al., 2013; Leaver & Reader, 2016a,b; Dekker, 2012). The risk management of a sporting organisation should encourage employee participation, identify and ameliorate risks within systems and promote adaptation (Guldenmund & Smibert, 2019; Atkinson, 2019; Jeffcott, et al., 2006). In the context of this incident the evidence suggests that the safety culture of AusCycling failed to ensure risk policies encouraged such behaviours within their workforce,

Rules and Regulations

The AusCycling (2022) report indicates AusCycling lacked a clear and coherent communication plan for the dissemination of safety rules, procedures, and training. This clear absence of training and guidance regarding the organisations internal rules and regulations represented 35.35% of all coded failures, with issues in safety training and drills and rule dissemination being prominent. The report tells of how instructions, policies and procedures were scant, over-reliant on the knowledge of employees, many of whom were un-informed or inexperienced within their roles (AusCycling, 2022). Interestingly, within the report there was only one mention of the UCI, as the international regulator of safety within track cycling. In the current context its mention was specific to the creation of time pressures placed upon AusCycling to have the bike ready for ‘presentation’. The lack of UCI specific insight within the report was a surprise to the research team, given their role within the sport as the guarantor of the proper application of ethical and sporting regulations.

Previous safety culture research from container terminals by (Lu and Yang, 2010) has shown that increased safety training leads to increased safety behaviour. In the healthcare setting this has also been found (Yao et al, 2013), with the work of Van der Molen, (2011) showing that without training workshops the likelihood of uptake of new safety equipment is reduced within the workforce. The lack of training and experience of AusCycling’s employees shaped the risk practices undertaken, again similar to that of BP Texas City (CSB, 2007). The testing followed incorrect and incomplete processes, and was undertaken by untrained personnel, some of the most obvious case of rules and regulations exploitation. There was an overwhelming culture of getting the job done as quickly as possible and following whatever method deemed most appropriate without any concerns raised, processes were incomplete and loosely defined, with errors tracing back to inadequate process and checking (AusCycling, 2022). The surrounding literature on safety culture has highlighted the importance of rules and regulations as a means of influencing behaviour and workplace culture (Leaver & Reader, 2019; Hopkins, 2011). It is imperative procedures are reflective of any, and all work undertaken, with protocols in place as a means of controlling risk, which includes audits of documentation and behaviour

to ensure companies with standard operating procedures. These procedures and protocols act as minimum standards employees must meet (Leaver & Reader, 2019), and are the bedrock of engineering reliability, employee behaviour, and safety in other high-risk industries such as aviation. For example, in a study of all major worldwide accidents between 1959 and 1983 by Sears (1986), pilot deviation from standard procedures accounted for 33%, with maintenance and inspection accounting for a further 12% of accidents. In review of the literature surrounding elite sports and rules and regulations as a dimension of safety culture, such standards are set both within the organisation itself, and externally, by the sport's governing body (Downie, 2021; IOC, 2018). Effective regulation from both governing bodies and within the organisation itself shapes the safety culture by defining expectations and norms on safety management. This is elaborated on further in the discussion section.

Systems

Systems (e.g., incident reporting, policies, monitoring systems) as a dimension of safety culture, are crucial for ensuring organisations identify risks and provide the appropriate resources for effectively managing and mitigating them. Whilst the dimension accounted for 16.16% of the coding, both sub-dimensions Organisation of System Access Rights and Systems Maintenance were not coded at all. The report revealed the majority of systematic problems fell under failures within resources as specifications were often not provided, thus denying developmental progress (AusCycling, 2022). The shortening of timeframes and altering of the geometric design of the cycle meant AusCycling were forced to have the frame manufactured locally (AusCycling, 2022). Further resource issues arose when relevant torque values went undisclosed to the manufacturer, along with AusCycling failing to provide complete specifications to outsourcers (AusCycling, 2022). The inadequate quality control documents coupled with incomplete specifications, meant that employees lacked a clear understanding of their assigned responsibilities within the system, rendering the monitoring and auditing of tasks, risks, or employees difficult. Research is indicative that management will find it difficult to evaluate, monitor, and control organisational risk without a reliable and transparent risk escalation mechanism. (Bryce, et al., 2013; Leaver & Reader, 2019). Whilst the AusCycling (2022) report does not mention systems related failures as a result of access rights and maintenance of the system, it is important to note how useful these sub-dimensions are in creating a successful organisational safety culture.

Much of the surrounding safety culture literature advocates the use of indicators as a line of risk defence and management, acting as a warning system in the detection of deficiencies and missed steps within protocol and safety management processes (Ogle, et al., 2013). The American Petroleum Institute (API) published a guidance report, suggesting several leading indicators which effectively measure and determine the quality of implementation of operational discipline and management system performance (Ogle, et al., 2013; API, 2010). One named indicator is "Fatigue Risk Management" (API, 2010), had

AusCycling implemented an advanced risk management system, their failure to comply with fatigue testing standards would have been raised and perhaps rectified prior to their Olympic failure as is the case in other industries such as aviation and maritime (Gander et al, 2011).

Collaboration/Organisational Communication

Collaboration and Organisational Communication in regard to risk (e.g., communicating threats to safety, raising concerns and intra/inter-departmental transitions) although found to support a successful safety culture, was the least codified dimension with regards to this incident. The absence of effective communication surrounding best practises would have led to uncertainty among performance and maintenance functions of AusCycling, and a lack of clarity regarding the utility of new regulations or collective regulatory responsibility. This is corroborated in the report, when it is stated that the workplace culture ‘did not support a disciplined conformance process’, with an AusCycling employee stating that the “closed shop environment” did not allow for procedures to be implemented or at least improved upon. This is suggestive of collaboration by exception as opposed to being the norm within the work environment. In review of the wider literature, previous research is indicative of strong organisational communication on potential risks, as established through training, is critical in the development of a strong organisational safety culture (Bisbey, et al., 2021; Vecchio-Sadus, 2007). It has been found by Hofmann and Stetzer (1998) that direct communication of safety information among workers affects both their perception of safety and its significance for their companies. The findings within the report also contrast with Gillespie et al, (2013) who indicate that within surgical theatres, hospital organisations who promote team communication, and team expectations of each other within theatre, led to enhanced safe performance within this setting.

Interventions such as cross-checking of a mechanics work on safety critical aspects at the micro level of the system such a torque setting on all human and track contact points of the bike (cockpit, saddle, crank, wheels) to ensure safety and reliability therefore become less divisive and more collaborative. A strong organisational communication network provides a cohesive and supportive framework in which individuals and systems may interact purposively and cooperatively (Vecchio-Sadus, 2007). The general work of Ashby et al (2018) and specific work of Noort et al (2019) talk about both the ‘formal’ and ‘informal communication of risk work being imperative for effective risk management systems within organisations, whether it be employee ‘safety voice’ or formalised reporting processes. This is also true in elite sport, as the literature shows that effective communication within a hierarchal system promotes an open environment for individuals and athletes (Wagstaff & Burton-White, 2018). Such an environment promotes autonomy and support for continued education and development within their roles, allowing individuals to perform better and thus, are more likely to experience sporting success (Wagstaff & Burton-White, 2018).

Discussion

The parallels between this incident and other in high risk-safety sensitive industries becomes apparent when the report is analysed using the lens of the Leaver and Reader (2019) safety culture framework as outlined above. Whilst the lack of adherence to rules and regulations in this current case mirrored those of BP Deepwater Horizon (Reader and O'Connor, 2014) within AusCycling, given their lack of adherence to ISO test protocols (not conducting the 150,000 fatigue cycles stipulated), but also within the UCI as the regulator more generally (light touch approach to equipment safety). Investigations of high-profile oil and gas accidents, such as Piper Alpha (Paté-Cornell, 1993), Texas City (Hopkins, 2008) and the Montara blowout (Hayes, 2012), all identify a lack of compliance with rules and procedures as a contributing cause in accident scenarios (Kvalheim and Dhal, 2016).

Effective regulation is important to ensuring norms of safety management are followed (Cox and Cheyne, 2000; Taylor, 1979). For example, a central aim of the FIA as the governing body of F1 is to *“Promote the development of motor sport, improving safety in motor sport, enacting, interpreting and enforcing common rules applicable to the organisation and the fair and equitable running of motor sport competitions”* (Article 2.3, FIA, 2023). As such the FIA ‘General Organisation’³ has governance structures in place that include a board member dedicated to safety who reports directly to the CEO on issues pertaining to motorsport safety. In 2004 the FIA created the ‘FIA Institute’ to enhance the development of new and improved safety technologies, facilitate higher standards of education and training, and raise awareness of safety issues. When compared to the UCI, (which interestingly makes no mention of safety in either its corporate values statement, mission statement, or vision statement) there is no comparable Director of Safety role at board level. Further, none of the UCI ‘Management Committee’⁴ members, nor the ‘Commissions’⁵ that sit under that committee, are dedicated to safety. On closer inspection of the terms of reference for the UCI Track Commission and UCI Road Commission, neither of them refers to safety whatsoever, nor do they have any executive or decision-making powers even if it was.

This is all suggestive of an international regulator who has failed to give safety the prominence that’s required within its sporting code. However, the UCI (2022) does state that *“The rules governing the use of equipment aim to ensure both the safety of riders and the fairness of competition while at the same time making the most of the advantages that technological evolution can bring to cycling”*. The use of ISO 4210 standards as the minimum safety requirements for equipment certification by the UCI

³ The ‘General Organisation’ is the terminology to describe the top-level managerial structure of the FIA that includes the CEO, board of directors, and President of the FIA.

⁴ The UCI ‘Management Committee’ is the executive body that manages the Federation, acting under the authority of Congress.

⁵ The UCI ‘Commissions’ are set up by the Management Committee to help it with its mission.

means it has absolved itself of any formal safety critical inspection duties, or the setting of any specific and prescriptive safety standards. Instead, it rubber stamps externally tested equipment with tests being conducted by those manufacturing the equipment, as was the case here. Given that AusCycling, and their supplier, didn't follow ISO standards to the letter, and still obtained certification to compete on the equipment at the Olympics it calls into question the robustness of this certification process, how seriously the UCI take safety, and the validity of any results obtained on the equipment within competition⁶. It could be argued that AusCycling had a light touch approach to safety rules and regulations, as that's how they perceive safety rules and regulations to be instilled at a 'macro' level by the UCI as the sport's international regulator (Salmon and Mclean, 2019). This supports the work of Ladyman et al (2013) and Sturmberg (2018) of 'top-down' causation when it comes to rider safety within professional cycling. Further, a review of the AusCycling governance structure and board sub-committees also reveals a similar pattern to that of the UCI - a fundamental lack of safety focus even if they do mention it in their vision statement. A situation not too dissimilar to that of the nuclear power regulator in Japan, and its dealings with TEPCO in the run up to the Fukushima Daichii Nuclear power station disaster in its creation of the *anzen shinwa* ('safety myth') (Noggerath, et al, 2011).

A lot can be learned by professional cycling at a national (AusCycling) and international (UCI) level from existing safety culture cases that have developed multi-level safety governance structures on mega projects. Tamkin and Lucy (2011) provide an exemplary case of safety governance within the 2012 London Olympics construction project. The leadership structure, that included multiple stakeholders, ensured that health and safety was 'fully embedded and facilitated collaborative working at all levels' (Tamkin and Lucy, 2011, p6). This structure also developed reporting mechanisms by which safety information could be reported from the top down and bottom up for safety interventions to be rapidly deployed, including anonymous near-miss reporting. In a similar vein the Office for Nuclear Regulation (ONR) has recently published a Technical Assessment Guide (TAG) that relates to corporate governance surrounding nuclear safety, radiation protection and radioactive waste management (ONR, 2023). It provides a corporate governance for safety framework based on 5 principles that include: Purpose and Leadership, Board Composition, Director Responsibilities, Opportunity and Risk, Remuneration, Stakeholder Relationships and Engagement.

In considering these principles, and how they were embedded within the London Olympic construction project, the UCI and AusCycling could reflect on the following questions relating to their own governance structures around safety:

1. Has our board established a clearly articulated purpose which encompasses safe operations within the sport?

⁶ The UCI (2022) state that "If a labelled model is tested and found not to conform but the manufacturer cannot be held responsible, the license holder is immediately disqualified and an investigation into the relevant team is opened", albeit it is not clear if this can be applied retrospectively.

2. Has safety been considered in decisions related to our board composition?
3. How has the authority, accountability, role and conduct of our directors in respect of safety been established within the management system arrangements of our organisation?
4. Is there an Internal Audit/Assurance Function that monitors safety risks and reports to our board?
5. How does our executive remuneration balance safety performance (behaviours and outcomes) alongside other factors such as programme delivery?
6. How does our board demonstrate that the organisation has undertaken effective engagement with stakeholders on safety matters, and that such dialogue has been considered in decision making?

The ‘safety myth’ in professional cycling is exacerbated by the fact that the parameters that determine ISO 4210 standards in this case fell well below the necessary thresholds, given that Olympic athletes can produce almost 1.5 times the force specified for ISO testing during the start-launch phase of the team-pursuit race (Aus Cycling, 2022). Key to their reliability, and ultimate safety, the actual loading conditions of the bicycle frame need to be considered (Tomaszewski, 2021; Mitchell, 2006; Blummel and Senner, 2010). The use of ISO 4210 standards as a safety baseline have been highlighted as inappropriate in previous research by Holzel et al, (2011) who state that “the actual test standards for bicycles are not adequate to ensure safe products”. Interestingly though, the UCI is not without precedent in carrying out inspection duties or setting specific requirements around equipment. However, it appears currently that it is more concerned about unfair aerodynamic gains by checking the height of a rider’s socks at a race start line, than it is about the actual safety of the rider (Ballinger, 2018). This is in stark contrast to other sports such as F1, as previously mentioned, safety and aerodynamic advantage are considered together from design right through to the yearly crash testing of equipment. These formal safety inspections are conducted under the watchful eye of an FIA representative using specific safety standards and regulations imposed by the FIA to reflect the risk and loads F1 cars and drivers are exposed to. Once again highlighting the difference in approach (and priority) with regards to driver/rider safety by both organisations.

Riders literally and metaphorically have the most ‘*skin in the game*’ when it comes to safety, as it is them who will be atop of the equipment should it fail, or beside a rider whose equipment fails during a race causing a crash. It is therefore incumbent on them to hold those responsible for managing their safety for them to account. However, unlike the GDPA in F1, the lack of an independent body that represents the safety and interests for riders, both on the track and road, is not as apparent, making it difficult for riders to lobby for change with their national or international federations, or hold race organisers accountable when it comes to safety concerns both at professional ‘trade teams’⁷, and at a national level. Arguably, the AusCycling (2022) report was only ever commissioned for public consumption because it happened in such a high-profile competition. For professional cyclists to lobby

⁷ A ‘trade team’ is the colloquial term known for a commercial professional cycling team on the track or road. Riders do not have to ride for their national federation but instead ride for privately owned teams, similar to that in football. E.g. a cyclist could ride for their ‘Trade Team’ on the road whilst representing their Nation on the track within the same season.

for change, as has been publicly requested by the likes of Matt Bostock in the opening quotation of this article, they need to be able to support their position using objective incident data, which at the moment is lacking within the sport.

Employee ‘safety’ voice is a critical part of any safety system that can assist in applying pressure for safety to be taken more seriously (Noort et al, 2019). The Cycle Reporting and Incident Tool (CRIT), is a new innovation that could be useful in this role within the ranks of professional cycling (McLean et al, 2022). This would allow for the collection, aggregation and analysis of data for riders, allowing them to report incidents that occur within and outside competition, building an evidence base for future safety action by those who represent them. The value in incident reporting, and data collection on accidents is clear to see in other industries such as aviation and other high-risk industries (Mahajan, 2010; Vanparjis et al, 2015). Further, it has been successfully deployed into industries that were previously lacking e.g. surgical wards and the hospital environment more generally (Vincent, 2007), and more recently by F1 with its £358k CrashTag technology, all of which is suggestive of an ability to make improvements within this current setting.

Within AusCycling the failures of management commitment to safety during the incident and other disasters such as the BP Texas City also involved is clear - a lack of effective oversight, production pressure, and the ‘run to failure’ of equipment are all apparent in both cases (CSB, 2007). All of which support the position that weak safety at the ‘macro’ level by the UCI has had a trickle-down effect on embeddedness at the ‘micro’ level within the employee practices of AusCycling. Ultimately, this manifested itself within the workforce as a poor belief in the importance of safety with artefacts of that mindset being evidenced through a failure to follow processes (e.g., handlebar servicing, reporting, and inspection) and guidance (e.g., following manufacturer torque settings). The work of Rubin et al (2020) supports this position, in their study miners who perceive it to be normal for miners at their mine site to ignore safety procedures were more likely to report taking safety risks in the future. The parallels between this, the AusCycling case in which mechanics arbitrarily chose torque settings coupled with a lack of handlebar service schedule reports, and the lucky escape of a Boeing 757 flight from Amsterdam to Kos carrying a full load of tourists, in which the bolt torques of engine blades had only been hand tightened is uncanny (Rackham, 1993). Effective communication has been seen in research from numerous industries to reduce risk within work environments, whether it be shift changeovers in hospitals (Jeffs et al, 2013; Mardis et al, 2016) or crew communication in nuclear power plants (Park, 2011). There was a clear lack of communication, and evidence of it occurring between stakeholders (e.g., the manufacturer was not aware of the AusCycling ‘Zero Failure Rate’ philosophy), and within AusCycling more generally (e.g., 41 of 50 projects having requirements that were all conveyed verbally). There is no denying that the specification of the base bar was incorrect, however the culmination of many other multi-level factors as outlined within this study led to a ‘system migration

to states of higher risk' (Leveson, 2011). This shift away from acceptable boundaries of safety, in the pursuit of better performance, led to an abrupt transition without adequate adaption that culminated in injury and sub-optimal performance (Trochim et al, 2006; Cilliers, 1998; Sturmberg, 2018; Hulme et al, 2020)

Conclusions

To the authors knowledge, this study is the first to investigate safety culture in the professional sport of track cycling, and professional cycling more generally. The previous research by Leaver and Reader (2019) was timely in this endeavour as it provides a conceptual framework in which to analyse incidents through the lens of organisational safety culture. In doing so, the results indicate that safety culture theory provides a useful lens through which to better understand safety related incidents within the socio-technical system of professional cycling when applied to the AusCycling (2002) incident during the Tokyo 2021 Olympic games. Our investigation reveals several instances where AusCycling's poor risk management and conflict between work (performance goals) and safety (regulatory and procedural adherence) compromised decisions and exacerbated mishaps – which are classic indicators of weak safety culture. Such conflict illustrates how the risk appetite and subsequent failure of safety standards can lead to disastrous consequences. The results of this research also indicate that safety culture is a necessary conceptual framework to understand such risk-related activities and can provide insight into the necessary organisational change and development to realign organisational safety culture.

Although this paper is the first to investigate safety culture within professional cycling there have been numerous studies that have addressed cycle safety in wider society using a variety of methodologies and data sources⁸. A limitation of our study is borne from the opportunity that was created due to the incident happening on a live broadcast during the Olympics in the first place. The need for answers as to why it happened by the general public and the international sporting community led to an independent investigation that culminated in a report that was made public. As can be seen in the discussion section, an attempt was made to triangulate this report (Podsakoff et al, 2003) with other secondary sources such as the ISO 4210 testing protocols, UCI/AusCycling/FIA annual reports, and other relevant safety related documentation within these bodies. Nonetheless, the focus of our approach centred on this report, and the source data contained within it, meaning we were reliant on it to assert the viability of safety culture within this current domain. For example, an omission from this report was any correspondence/interviews conducted with the UCI or International Olympic Committee given their role as international regulators and organisers. Secondly, this incident occurred indoors on a velodrome track, as such the cross-pollination of findings and interventions between this domain and others such as road cycling should be sensitive to any increased complexity within the system. Finally, there are

⁸See Salmon et al (2022) for a systematic review of the literature

theoretical ‘lens’ other than safety culture that could be placed over this incident to investigate its occurrence such as the ‘Competing Values Framework’ (Cameron and Quinn, 2006).

In the future there will be a need for further theoretical and empirical contributions as the safety related discussions of professional cycling both within the sport and wider mainstream media continues to grow. All of which is timely given the scenes in stage 1 of the 2023 Vuelta a Espana, cancellation of the CIC-Tour Feminin International des Pyrénées 2023 for safety concerns raised by the riders, and the tragic death of cyclist Gino Mader at the Tour De Suisse in June 2023. Given the findings of this study, and the limitations outlined above, future research could feasibly address multiple historic incidents that fall under the UCI purview from multiple cycling disciplines allowing for greater clarity on the interrelationships within the system and the interventions required. For example, the creation and aggregation of an incident database would allow for analysis methods such as STAMP-CAST-STPA frameworks to be applied to support the identification of risk and safety interventions across system levels from the macro to the micro (Hulme et al, 2023), whilst answering the call by Hulme et al (2021) to employ risk analysis techniques in new contexts such as professional sport. This could also be complemented by conducting surveys of stakeholders within the system similar of that of Jing et al (2023), with a focus on those with the greatest exposure to risk within it – the riders. In doing so, future research would allow for greater awareness of safety critical aspects of the system through the eyes of those with the least heard safety voice, yet the most to lose.

Ultimately, riders can’t win races if they don’t finish, and strength training is irrelevant with weak equipment. Therefore, cycling federations, ‘trade teams’, race organisers, riders, and the UCI as the international regulator of safety within professional cycling should consider the management of risk and safety culture within their organisations to improve the likelihood of success from a commercial, welfare, and sporting sense.

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