Artifacts

UNIVERSITY OF MISSOURI

ISSUE NO. 22 SUMMER 2024

Effects of Animal Agriculture on Disease Spread

Danielle Walters

"We are Right on the Cusp of Some Bad Stuff Happening": Life and Death on a Missouri Farm

Colbey M. Stosberg

Thoroughbred Horse Racing Safety Regulations

Kaitlynn Myers

Effects of Animal Agriculture on Disease Spread

Danielle Walters

Introduction

The post-COVID-19 world has become more aware of the possibility of disease outbreaks and potential future health risks than in previous years. Issues concerning the future welfare of populations have come to the forefront of the public mind. Developing resistance to antibiotic drugs is a leading cause for concern. The animal agriculture industry uses antibiotics to increase the welfare of livestock animals and to prevent or treat disease. Criticisms arise regarding the implications of antibiotic use within food animals as it concerns human health through zoonotic transmission, and the distribution of disease from animals to humans and vice versa (Cella et al., 2023). While there are various animal-specific antibiotics, many of the antibiotics used in animal agriculture are the same antibiotics used to treat humans. Widespread antibiotic usage in livestock creates the risk for antibiotic resistance; while providing benefits for animal welfare and production, the consequence of antibiotic resistance and potential human disease outbreaks is a major concern.

What is Antibiotic Resistance?

Antibiotics are a widely distributed drug due to their ability to provide treatment for a variety of bacterial infections and prevent the spread of disease. Antibiotic resistance is a growing health concern for all populations, both humans and animals. Resistance is described as the ability of bacteria to grow and evolve, to reduce, or to eliminate the effectiveness of antibiotics (Cella et al., 2023). The phenomenon of antibiotic resistance has been long documented since first becoming prevalent in the 1960s (Economou and Gousia, 2015). Reasons for the further evolution of antimicrobial resistance include the misuse and overuse of antibiotics in humans and animals, international travel, overseas trade of goods including livestock animals, and the lack of new medicinal development and alternative options (Argudín et al., 2017). Since some older antibiotics have large issues with resistance, newer novel antibiotics are slowly being developed to combat current forms of resistance in all species.

The health of humans is directly correlated to the health of animals, and the development of resistance to antibiotics challenges the future of current medical practices. One Health is a contemporary all-encompassing strategy for the simultaneous medical treatment of animal, human, and environmental health outbreaks (Cella et al., 2023). One Health recommends a holistic

Artifacts
UNIVERSITY OF MISSOURI

About the Author

Danielle Walters

My name is Danielle Walters, I am an undergraduate student from Saint Louis, Missouri. I am pursuing a bachelor's degree in animal sciences with a minor in captive wild animal management at the University of Missouri–Columbia. Postgraduate I plan to apply to graduate school to obtain a master's degree in animal science and obtain a position in the conservation field.

Artifacts, Issue 22,

cwp.missouri.edu

approach and the integration of communication between human healthcare professionals, veterinarians, and rural communities regarding the proper administration of antibiotics within all regions of health (Cella et al., 2023). The positive correlation between the health of the planet and its populations sets a precedent for maintaining communal health with the support of antibiotic drugs.

Antibiotics are commonly used for human infections including strep throat, urinary tract infections, upper respiratory tract infections/pneumonia, and mastitis. Mastitis is seen in both humans and livestock, most notably in dairy cattle. Misuse of antibiotics occurs when the drugs are overprescribed or prescribed for incorrect use such as the treatment of viral infections. The continued degradation of the effectiveness of antibiotics leads to significant concerns for post-surgery patients, immunocompromised individuals, and a concern for the control of disease outbreaks (Cella et al., 2023). According to the Centers for Disease Control and Prevention, in 2013 it was approximated that infections derived from antimicrobial-resistant bacteria totaled 23,000 casualties annually in the United States (Chang et al., 2015). Over the next six years, the affected number grew significantly within the US alone. In 2019, it was estimated a total of 1.27 million deaths were due to antibiotic resistance, making the issue one of the top global threats to current and future generations (Lake et al., 2022). Further figures suggest that by the year 2050, antibiotic-resistant-related deaths will reach 10 million globally (Tian et al., 2021). The use and misuse of antibiotics can lead to poor outcomes for both human and animal medicine practice.

Antibiotic Use in Animal Agriculture

Antibiotic use in animal agriculture promotes animal welfare and is used for disease-preventative purposes but still contributes to the widespread issue of antibiotic resistance. Veterinarians administer antibiotics to treat, control, and prevent illness in livestock species, and for therapeutic purposes like relieving pain caused by illness and improving production (Karavolias et al., 2018). Without the use of antibiotics in animals, welfare would decline significantly due to the increased severity of illness/infection and prolonged periods of suffering (Karavolias et al., 2018). Overcrowding and stress within large-scale livestock operations have a negative effect on the immune systems of affected animals. Higher stress levels and poor immune system responses lead to a higher chance of infection (Karavolias et al., 2018). Antibiotics have shown over time to be necessary within animal agriculture to maintain welfare and promote healthy herds, but there remains a feeling of unease due to the implications on humans.

Criticism regarding the use of antibiotics in animal agriculture believes that the industry is a leading factor in the rise of resistance. Approximately 80% of antibiotics used in the United States annually are administered to livestock species as growth supplementation and for preventative measures which, are not always clinically indicated from a medical standpoint (Chang et al., 2015). While the administration of low-dose antibiotics for weight gain is still practiced in the United States, it was banned by Europe in 2006 (Economou and Gousia, 2015). Another example of suboptimal antibiotic usage in animals is the administration of antibiotics to dairy cows at the end of the lactation cycle to prevent mastitis. Administration of the preventative antibiotic drug occurs for all animals, not only the ones currently exhibiting signs of an active infection.

The correlation between high resistance rates both in animals and humans has been displayed in numerous studies A research group reported a comparable relationship between food-animal and human resistance rates, highlighting that a decrease in the use of antibiotics in animals caused a decrease in resistance to the animals and humans in direct contact with those animals (Vidovic and Vidovic, 2020). Antibiotic abuse in livestock species presents several concerns for both the animals and humans. Overuse of antibiotics affects the health of livestock by damaging the immune system, giving further chance of infection, and leaving drug residue within manure and the surrounding environment (Tian et al., 2021). Despite the ability of antibiotics to cure and prevent infection, overuse can increase infection rates, cause secondary infection, and even lead to severe infections such as sepsis/organ failure in humans.

Effects of Antibiotic Resistance on Humans

Antibiotic resistance can be transmitted to humans from livestock species in three different methods. The primary routes of transmission occur through:

direct contact with livestock animals, contaminated water, and food;
secondary human contact; and
horizontal gene transfer (Chang et al., 2015).

Individuals who have frequent direct contact with resistant livestock species are at a higher risk of antibiotic resistance transfer (Tang et al., 2017). Strains of livestock-specific resistant Staphylococcus aureus have been reported in farmers and individuals closely in contact with contaminated pigs (Economou and Gousia, 2015). Due to the increased health risks within the environment maintaining adequate farm labor can be an increased challenge.

Another form of direct animal contact is through the consumption of food animals. The use of antibiotics in food animals, mainly swine and poultry, was noted to have transmitted vancomycin-resistant bacteria to humans through protein (El-Dien and Ahmed, 2018). Contaminated water sources have the further ability to transmit resistance as both a drinking source and through the consumption of fish. Seafood can be a carrier of bacteria with resistant genes derived from living in polluted water sources. Cross-contamination/pollution provides another route of access for resistance into the food chain system (Tian et al., 2021). The degradation and pollution of water pose a threat to survivability for all populations, as well as leaving antibiotic resistance residue within the animal protein.

The second method of the acquisition of resistant pathogens from animals occurs through human-to-human contact. Similar to other forms of bacteria, modes of resistant bacteria transmission include touching infected surfaces, direct/close contact with sick individuals, airborne routes such as coughing/droplets, and through mucus membranes. Lack of proper diagnosis of infection and inadequate isolation measures allow the spread of resistant organisms to other non-infected individuals (Cella et al., 2023). The third mode of antibiotic resistance from livestock to humans occurs by horizontal gene transfer. Horizontal gene transfer is a process in which resistance is transferred among bacteria giving a significant spread of resistant genes as they mutate from organism to organism (Vidovic and Vidovic, 2020). Bacteria become more resistant as they mutate degrading the effectiveness of certain classes of antibiotics as resistance is developed.

Correlation Between Antibiotic Resistance and Disease Transmission

The future of both human and animal populations and their health is dependent on the outcome of antibiotic resistance. The recent COVID-19 pandemic brought attention to the possibility of antibiotic resistance being a plausible contributor to the next global pandemic. Animal husbandry relies on antibiotics to prevent, treat, and control disease within a large group of animals. A study evaluating the correlation between animal use of antibiotics and the presence of antibiotic-resistant genes in humans suggests animal agriculture has a more significant impact on the spread of resistance than the human medical counterpart (Hu et al., 2014). There is a classification of animal-only antibiotics named ionophores, which the Food and Drug Administration identified as “non-medically important” for humans as they do not factor into the issue of antimicrobial resistance (Karavolias et al., 2018). Despite the ionophore antibiotic class being deemed as not influential to resistance in humans, poultry producers are not able to use the specific drug class within production under the regulations of the United States Department of Agriculture and its antibiotic-free label (Karavolias et al., 2018). The multiple modes of transmission from animal to human correlate to a higher risk of resistance distribution.

In addition to animal agriculture, human medicine provides an additional source of antibiotic resistance. According to One Health, following the COVID-19 pandemic the overprescribing of antimicrobials greatly increased especially in second and third-world countries (Cella et al., 2023). A 2021 study determined the effects of antibiotics during the COVID-19 pandemic displayed a higher rate of resistance genes in infected patients (Lai et al., 2021). The study provided support and displayed resistance stemming from human use of antibiotics through the example of resistance

development in the recent pandemic. The transmission of resistance comes from both human use and from the use within animal husbandry.

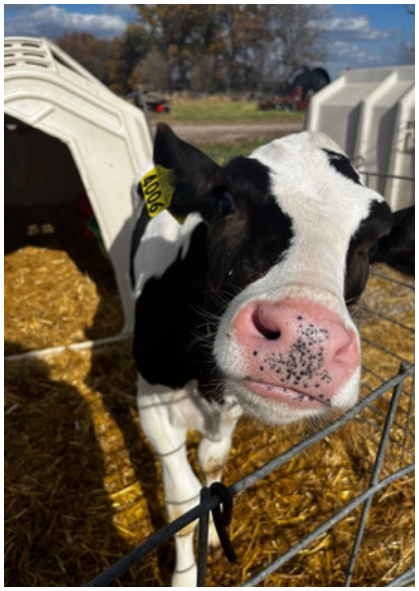
Summary

Antibiotic resistance is a concern for all. The decline in the ability of antibiotics to treat bacterial infections raises unease regarding the future of Western medicine. The rapid development of resistance has been shown to have stemmed from the overuse and misuse of antibiotic drugs in both human and animal medicinal applications (Argudín et al., 2017). Animal agriculture administers antibiotics for many factors primarily to treat, prevent, and cure certain bacterial infections (Karvolias et al., 2018). However, the abuse of such antibiotics can fortify resistance and ultimately be transmitted to humans. Modes of transmission from livestock to humans include direct contact with animals, passage through polluted water and protein, human-to-human contact, and horizontal gene transfer (Chang et al., 2015). The use of antibiotics is essential for maintaining the welfare of livestock animals however, human medicine also contributes to the issue of resistance.

The overuse and consequential misuse of antibiotics in both the animal agriculture industry and human medicine practices lead to the development of antibiotic resistance. The World Health Organization describes antibiotic resistance as not only a major concern for world health but also poses a severe danger to both the production of food and the total global supply (Cella et al., 2023). Treatment of non-bacterial infections remains a leading factor in the misuse of antibiotic drugs. Following the COVID-19 pandemic, antibiotic resistance has become and remained a point of discussion concerning the eventual state of modern medicine. Proper antibiotic stewardship remains a necessary step toward maintaining the effectiveness of antibiotics currently in use.

Recommendation

Animal agriculture and human medicine are both responsible for the development of antibiotic resistance. The first step towards managing the further evolution of resistance is to practice good antibiotic stewardship and provide alternative care methods for maintaining livestock health. The correlation between animal agriculture and the possible next widespread disease outbreak exists; however, it is not the sole contributor. Practicing good antibiotic stewardship by only prescribing for needed or necessary infections is essential to lowering the rate of development and eventual inter-species transmission of resistance. However, there are other options for maintaining animal health rather than reliance on antibiotics.



Dairy calf pictured within its individual calf pen with hutch.

The One Health ideology connects the health of animals, humans, and the environment. The principle of One Health not only applies to the outside environment but also to the captive environment of the animals. Management of the environment where the livestock animals are produced is fundamental to promoting animal health, practices including cleanliness, housing, concentration of animals, and nutrition. Studies have shown that issues such as overcrowding and stress caused by handling lead to an increase in disease susceptibility and negatively affected the welfare of the animals (Karavolias et al., 2018). The issue would be lessened or resolved through the reduced use of antibiotics. Two separate studies reported a relationship between antibiotics in livestock, stating a reduction in the use of antibiotic drugs was paralleled by lower rates of resistance documented in humans with direct contact with affected animals (Vidovic and Vidovic, 2020). Resistance will continue to be a factor for generations to come, but finding alternative options for treatment would be favorable for slowing the rate of transmission and avoiding disease outbreaks.

References:

Argudín, M., A. Deplano, A. Meghraoui, M. Dodémont, A. Heinrichs, O. Denis, C. Nonhoff, and S. Roisin. 2017. Bacteria from animals as a pool of antimicrobial resistance genes. Antibiotics. 6(12):1-38.

Cella, E., M. Giovanetti, F. Benedetti, F. Scarpa, C. Johnston, A. Borsetti, G. Ceccarelli, T. Azarian, D. Zella, and M. Ciccozzi. 2023. Joining forces against antibiotic resistance: The One Health Solution. Pathogens. 12:1-14.

Chang, Q., W. Wang, G. Regev-Yochay, M. Lipsitch, and W. P. Hanage. 2015. Antibiotics in agriculture and the risk to human health: how worried should we be? Evolutionary Applications. 8:240–247.

Economou, V., and P. Gousia. 2015. Agriculture and food animals as a source of antimicrobial-resistant bacteria. Infection and Drug Resistance. 8:49–61.

El-Dein Saad, M. M., and M. B. Ahmed. 2018. Necessary usage of antibiotics in animals. In: Antibiotic Use in Animals. National Research Centre, Cairo, Egypt. p. 10–23. Available from: https://www.intechopen.com/chapters/57280

Hu, Y., X. Yang, N. Lu, and B. Zhu. 2014. The abundance of antibiotic resistance genes in human guts has correlation to the consumption of antibiotics in animal. Gut Microbes. 5:245–249.

Karavolias, J., M. J. Salois, K. T. Baker, and K. Watkins. 2018. Raised without antibiotics: Impact on animal welfare and implications for food policy. Translational Animal Science. 2:337–348.

Lai, C.-C., S.-Y. Chen, W.-C. Ko, and P.-R. Hsueh. 2021. Increased antimicrobial resistance during the COVID-19 pandemic. International Journal of Antimicrobial Agents. 57(4):1-6.

Lake, S. J., S. R. Van Katwyk, and S. J. Hoffman. 2022. Antimicrobial resistance must be included in the pandemic instrument to ensure future global pandemic readiness. Journal of Law, Medicine & Ethics. 50:9–16.

Tang, K. L., N. P. Caffrey, D. B. Nóbrega, S. C. Cork, P. E. Ronksley, H. W. Barkema, A. J. Polachek, H. Ganshorn, N. Sharma, J. D. Kellner, and W. A. Ghali. 2017. Restricting the use of antibiotics in food-producing animals and its associations with antibiotic resistance in food-producing animals and human beings: a systematic review and meta-analysis. The Lancet Planetary Health. 1:E316–E327.

Tian, M., X. He, Y. Feng, W. Wang, H. Chen, M. Gong, D. Liu, J. L. Clarke, and A. van Eerde. 2021. Pollution by antibiotics and antimicrobial resistance in livestock and poultry manure in China, and countermeasures. Antibiotics. 10(5):1-16.
Vidovic, N., and S. Vidovic. 2020. Antimicrobial resistance and food animals: Influence of livestock environment on the emergence and dissemination of antimicrobial resistance. Antibiotics. 9(2):1-15.

"We are Right on the Cusp of Some Bad Stuff Happening": Life and Death on a Missouri Farm

Colbey M. Stosberg

Marmee's house is damn near the oldest thing in all of Lafayette County. The place is an oddity. As you walk past the rusted-out playset on the lawn, ascend the stairs to the front porch, and pass through the screen door, Marmee is there. Beyond the mud room and laundry, a wire basket hangs filled to the rim with full-size Snickers bars. Marmee loves Snickers. The drink fridge is stocked with Pepsi, Sunkist, and water. "Grab a Snickers and a drink." Just like the animals, Marmee's company is always well-fed and watered. In the summer, the freezer above is always loaded with the delicious Wal-Mart brand ice pops that come in red mesh bags. Those things are cheap but damn good.

The soft, dark blue carpets and low ceilings make the living room feel smaller than it is. This, of course, is no problem for the short-statured Marmee. The distinct smell of Dial body wash fills the hallway, whose oddly sloped floor makes for optimal "scooter-riding," although Marmee does not enjoy scooter riding in the house. At the end of the corridor is the linoleum-floored kitchen. Marmee prepares hearty chicken fried steak and pork chops. The sides of the staircase just beyond Marmee's bedroom are lined with extra canned veggies, paper towels, and clothes. It is an extraordinary place to put lima beans, but considering it is impossible to open the pantry without everything falling out, it makes sense.

In 1821, no more than ten miles from Marmee's house, a man named Adam Lightner operated a ferry across Tabo Creek in present-day Lafayette County, Missouri. This ferry transported William Becknell's party across the creek on his inaugural trade expedition along the Santa Fe Trail. Nearby pioneers began homesteading, hoping to make a living despite scattered settlements and little infrastructure. More than two hundred years later, on the banks of Tabo Creek and a land littered with history, Marmee and her son Mike Williams operate a 773-acre farm on some of the finest land in all of Lafayette County–and even the state of Missouri itself.

Published in 1910, William Young's History of Lafayette County mentions the same attractive geographical features that my uncle Mike hypothesizes drew settlers to this area in the first place: quality streams, a healthy combination of timber and good open ground, wildlife, access to transportation, and more. The agreement between Young's and Mike's assessments is astounding, especially considering that my uncle hasn't read a lick of Young's work.

Artifacts
UNIVERSITY OF MISSOURI

About the Author

Colbey M. Stosberg

I am a fourth-semester Political Science major and Geography minor Mizzou student, with an anticipated graduation in the Fall of 2024. As a lifelong Missourian, whose family has ancestry in the state since the 1810s, I have an extreme passion for all things relating to this state. I am interested in Missouri Politics and am currently employed as a staffer on a major statewide campaign and was an intern in the office of Majority Floor Leader and Speaker-Elect Dr. Jonathan Patterson. Geography has always been an interest of mine, and I had a collection of maps as a kid. I enjoy learning, visiting, and writing about new places, so writing this paper was a real treat for me. I grew up on the western side of the state in the South KC suburbs as a huge Mizzou fan and was even Truman the Tiger for Halloween on several occasions.

Artifacts, Issue 22,

cwp.missouri.edu

Despite over a century of separation, both men intuitively understand that the things that drew settlers to the farm were not gold or other far-fetched Western offerings. The landscape is a habitat for them, their families, livestock, and crops. Despite more than a century of drastic change, Mike's engrained respect for the land endures.

Mary Marshall Bear poses for a photo in front of the farmhouse. While abstracts for the farm trace back to the 1830s, the house was built in the 1860s. This photo was taken at an unknown date following the construction of the house.

The antique family farmhouse, a Victorian-era gable-front-and-wing, is the centerpiece of the farm lifestyle. It was built by John P. and Mary Marshall Bear sometime in the 1860s, and in an odd twist, the property was owned in succession by families whose last names proceed like an animal menagerie: Bears, Foxes, and Lyons**.** In March of 1952, Earl "Tootie" and Pat Williams moved into the farmhouse and began renting the farm, about 200 acres, from Mr. Lewis Rechterman, eventually purchasing the farm ten years later in the final months of 1962. Working the land, Earl and Pat reared five children, Linda, Mike, Shelley, Susan, and Lori, on the farm. The siblings have their own children now, me among them, who, along with the grandchildren, call Earl "Pawpaw" and Pat "Marmee." After at least 150 years of ancestors in Lafayette County. and seven decades on the farm outside of Higginsville, the Williams family has developed an extremely tight bond with the land. There are indications that the exact land that my family currently owns was directly inhabited as early as 1836 by white settlers. Considering the population density of Lafayette County in 1830 was less than five people per square mile, the location says something special about the quality of the land: with a relative abundance of open ground available for settlers to choose from, the fact that a family chose to farm and build a home there indicates a prime location.

The farm primarily grows corn and beans. Although these crops are extremely important to the livelihood of the farm, the cardinal focus and area of expertise has been the Hampshire pig. The Williams family has bred and raised this specific breed of swine since 1947, when Earl was in high school. Hampshire hogs have shaped and dominated our family's identity.

Roughneck, the magnum opus of the Williams' hog tradition, sits in Mike's garage to greet visitors.

Working with Hampshires not only had a lasting financial impact on the development and improvement of the family farm, but also played a central role in the upbringing of each of Marmee and Pawpaw's children, grandchildren, and great-grandchildren. The Hampshires, like the record-holding "Roughneck" of the 1970s whose skeleton was on display at the American Royal in Kansas City and now resides in Mike's garage, are a source of pride. The Williams farm sign, planted firmly at the intersection of Highway FF and Brush Creek Road, features a Hampshire pig, and whether you're in the farmhouse or the home of any one of the five siblings, you will find an abundance of Hampshire photos, pictures, statues, and figurines.

Everyone in the Williams family understands the great historical, social, and economic value of the farm, but no one is more attached to the landscape than Mike. Mike has more than 50 years of experience as a farmer and his hard work and dedication to the farm are evident in every aspect of his life. This includes his body. In 1958, when Mike was

Mike, like all farmers, checks on his crops regularly during the growing season, this time using his hand with all five fingers. High quantity and quality are essential features of a quality corn or bean crop.

only six years old, the index finger on his right hand was amputated by a wheat drill. Hanging by a thread, doctors attempted to sew the finger back on, but to no avail. You only notice the effects of the injury when Mike grasps you in a handshake, which is so firm that you can feel the missing digit as a merciful absence in the compression.

For Mike, the uniqueness of the land lies not only in the quality of the soil but also in the geographic location. “Over the summer, moisture and precipitation tend to follow the river. My thoughts are, it's about ten miles either side of the river that tends to catch the most moisture when the rains blow down the river. We are about that distance. From year to year regarding moisture for making high-yield corn and beans, we are in a very good area for that.” Although the farm lies firmly in the bounds of Mike's ten-mile theory, last year was tough on the south side of the river. “We need some substantial water. Our ponds are 3-4 feet down. Up to last week, you could walk across Tabo. In thirty years, I cannot hardly remember that happening. We are right on the cusp of some bad stuff happening.”

The bad stuff doesn’t end with the lack of rain. Raising livestock and farming has always attracted the ire of ”so-called environmentalists”. Accusations by environmentalists have led Mike to feel that outside parties are misinformed about the practices of his farm, not to mention the ignorance over the hard work Mike has done as the caretaker and conservationist of the land. Mike has swift responses to each of the environmentalist’s contentions. Regarding the concerns on erosion, he points to the practice of terracing. To the concerns regarding the destruction of habitat, he points to the extremely fertile soil or timber laden with foliage and wildlife. Mike retorts, “I think we are very humane. In fact, there’s many days where we’ve been out trying to take care of the animals where it has been quite a detriment to our own health. It’s real simple. If we don’t take care of the land, then the land won’t take care of us. And all of the people who consider themselves environmentalists or are people who have problems with agriculture and farming, they do not understand whatsoever how important the land is to our survival and their survival. Environmentalists are a threat, especially to smaller farms like ours, because a family farm doesn’t have the financial power to fight some legal battle that they want to fight.” Respect for the land, the flora, and the fauna are priorities for environmentalist groups, animal activists, and Mike. This is a vital common ground. Just recently, Mike himself was rammed by a tusk from an angry boar, barely missing his femoral artery and yet another potentially fatal experience. Yet, Mike continues caring for his animals.

While gilts are female pigs produced for consumption, sows, like the two pictured above, are females who have had at least one litter of pigs. The piglets in this litter are yet to be weaned off their mother and are still nursing in the farrowing house.

The number of small farms in the United States has been declining steadily for decades. Mike believes that farms must operate a certain acreage to be profitable or self-sufficient. He explains that all farms must have a "baseline" amount of resources and equipment, so if farms do not have enough land to offset these baseline costs, then profitability is impossible.

Assuming Mike’s theory is true, the relationship between expenses and output is not strictly linear, so margins can decrease rapidly for smaller farms. Mike believes the farm is dangerously close to that profitability threshold. For Mike, outside forces and foes are not the only thing threatening the small farm. Fighting and disagreements within and between families and partners--potential heirs--combined with hefty inheritance taxes cause family farms to slip below the land threshold and fall into sale and often, subdivision. Marmee and Pawpaw raised their five children with what

they call a "mutual understanding." This mutual understanding involves each of the kids realizing that what is best for their personal interests may not align with what would be best for the family and, in turn, the farm, which is what Marmee and Pawpaw dedicated their entire lives to provide for and protect. Each of the four other children has no stake in the farm. Despite this, Mike has prioritized his siblings and involved them in the discussions on the home farm. The understanding between the siblings and their parents overcame personal desires, each knowing that it would be impossible to split the farm two, let alone five ways. Along with this, Mike has spent decades working on the farm just to ensure the farm's survival. Still, the question remains: who will take over after Mike? His daughter lives outside of St. Louis, nearly 200 miles away from Lafayette County, and while Mike's son currently resides on the farm, he has a family and business of his own. A few things are clear: Mike's children must keep the farm whole, and they must work together with their father to develop a plan. The Williams family farm will inevitably disappear if they cannot do this.

Brand new combines and tractors often cost more than a house. Smaller farms like Mike's are forced to lease or buy older equipment. As agriculture technology rapidly advances, this could put some farms at a disadvantage.

On New Year's Eve 2022, Marmee passed away at her home in town. I was concerned with Marmee's passing, considering this was the first loss in the family since I have been alive. The Higginsville Methodist church pews were packed, with story after story being shared by friends and family. My mother and maternal grandmother (unrelated to Marmee) made the two-hour round-trip journey from home to come, even though my parents divorced over 10 years ago. If that is not indicative of the character that Marmee displayed, then I don't know what is. Heck, my stepfather came, and he never even knew Marmee.

I was granted the chance to speak in front of several hundred folks at the funeral. In my speech, I decided it would be appropriate to talk about the countless stories we had about Marmee. I had pre-written the address but knew my delivery and tone would have to be based on the emotions in the room on the funeral day. I gauged the room, a small-town church that was cozy, yet dramatic, with impressive stained glass windows. I expected to see the usual somber vibe surrounding a funeral, but I observed something different. The room was filled with awkward happiness. Everyone missed Marmee, yes, but everyone also knew her life was spectacular, filled with dedication to her earthly family and farm, living with a deep conviction and commitment to her faith.

I briefly considered sharing the hilarious story of 90-year-old Marmee sipping a Busch Light through a fluorescent orange straw on Thanksgiving Day. However, I soon determined that the story would be inappropriate in a place of worship. I instead saved that hilarious story for later. On that Thanksgiving Day, Marmee spotted one of the men watching the football game and drinking a beer. She promptly said, "Get me one of them." So, we did just that. She sipped on it for a while, and when Susan tried to take it away, she got upset and said, "I'm not done." Her voice was weak, but you knew damn well not to take Marmee's Busch Light away. It is the beer of the farmers, after all.

Instead, I opted to share something different. In the fall of 1977, Marmee was headed home in the very early hours of the morning from southern Missouri in a severe rainstorm. As she was crossing the bridge on Brush Creek Rd. just north of the confluence of Brush and Tabo Creeks, she believed the rising water on the bridge was no more than a few inches deep. In a near-new 1977 Chevrolet Caprice, Marmee figured she would have no problem crossing the bridge everyone in the family traveled daily. She was wrong. The floodwaters swept her off the bridge and into the creek. Marmee miraculously managed to climb out of the car and the gulch and made the two-mile trek in the dark downpour all the way back to the farmhouse, arriving soaked just before dawn. Marm's car was recovered, but totally laden with silt, sand, mud, plant debris, and just about anything nasty you could find in a rural creek. Among other near disasters were the

time Marmee was nearly suffocated by snow when she was putting snow chains on her vehicle in a blizzard, just as a snowplow drove by and buried her underneath her vehicle. This was no match for Marmee, as she dug herself out with her hands and continued on her way. When she was 89 years old, Marmee tried to take out the trash on the coldest day of the entire winter while wearing just a light coat. She slipped, fell, and was stranded for hours in the snow before she was found. Her skin was frozen to the snow as the EMTs attempted to rescue her. Her body temperature fell to below 80 degrees, and we were sure she would not make it through the night. Despite losing several digits to severe frostbite, Marmee fought on, as she always had, and lived another two years.

Marmee (center), my twin sister, Kayden (right), and my cousin Clayton (back), and myself (left) in March 2017

Marmee was weak and frail for several years before her death. To be honest, several of us were wondering why she had not gone to be with Pawpaw earlier, considering her condition. My aunt often spoke with Marmee, and Marmee told her that she was worried Pawpaw was not there waiting for her in heaven. I was heartbroken to hear this and still get choked up thinking about this. This was not like Marmee, who was so steadfast in her faith. I found Marmee's concerns on the afterlife especially alarming considering the numerous near-death experiences she has had. Eventually, my grandmother decided to visit the psychic. The psychic even confirmed and assured Marmee that Pawpaw was waiting right there for her on the other side. Even the strongest Christians like Marmee doubt their faith. In times of doubt, I truly believe faith becomes more fortified. After Christmas, I think Marmee was able to let go and go be with her husband, whom she so dearly missed as a widow of nearly three decades. She never remarried. Marmee passed away just hours before midnight on New Year's Eve. It was a peaceful passing for the most deserving woman. There is no doubt in my mind that Marmee is reunited with Pawpaw. In the words of my cousin, "Marmee got the New Year's kiss she had been waiting on all those years." We can only pray, now with Marmee gone, that the legacy of the farm and ancient house will survive. The rows of corn and beans, the terraces, the hogs and cattle, and the age-old farmhouse all are examples and proof that the land is truly connected with the family. The connection to their land and each other is ultimately what will have the potential to immortalize the farm and the house against threats of all shapes and sizes. For now, the farmhouse, the oldest thing in Lafayette County, will lie empty, waiting to be bulldozed, Marmee is no longer there to greet its visitors.

Thoroughbred Horse Racing Safety Regulations

Kaitlynn Myers

Introduction

Horse racing faces many challenges in modern-day society and the once famous “sport of kings” is in danger of becoming a thing of the past. In the United States alone, the horse industry contributes more than $122 billion to the economy annually (Bull, 2023). Horse racing contributes over $30 billion and is one of the largest entertainment and sporting industries (Bull, 2023). However, the sport is facing major challenges with concerns for the safety of its equine and human participants. Horse racing's future depends on the safety of horses and jockeys, the implementation of new technology to improve the industry, and an evaluation of the impact of both new and existing regulations on the sport.

Horse Safety

Safety concerns have plagued the industry for several years due to the injury rate of horses and jockeys. During the 2023 summer meet at Saratoga Race Course, located in Saratoga Spring, New York, a string of eleven fatal breakdowns brought national attention (Hegarty, 2023). Breakdowns are defined as injuries that are or could be career-ending (Saratoga Race Course, 2024). Instances of horses failing to finish a race are relatively infrequent, occurring at a rate of 2.88 times per 1000 races, which includes falls, injury, and poor performance (Tanner et al., 2016). Age has no significant impact on the incidence of failure to finish a race, including younger horses at three years of age and older horses over six years of age (Tanner et al., 2016). However, older horses are more prone to failing to finish due to injury (Rosanowski et al., 2018). Furthermore, performance data indicates that 80% of horses’ performance peaks before the age of six, with the average age for reaching peak performance falling between 4.25 and 4.50 years (Gramm and Marksteiner, 2010). Horses typically experience greater performance improvement between the ages of 2 and 4.5 years than beyond 4.5 years (Gramm and Marksteiner, 2010). While age and performance related data does provide some insight into the rate of injuries and breakdowns, it is evident that there are other underlying factors that contribute to the recent surge in breakdowns and injuries at Saratoga.

Horse races vary in length, ranging from short, sprinter-type races to longer, distance-type races, spanning from 5 furlongs to 36 furlongs (Dooley, 2024). A furlong is equivalent to one-eighth of a mile or roughly 201 meters (Dooley, 2024). Juvenile horses will begin racing at 5 furlongs as early as January of

Artifacts
UNIVERSITY OF MISSOURI

About the Author

Kaitlynn Myers

I'm from the tiny town of Port Hudson, Missouri. I grew up showing quarter horses around the country in western pleasure and hunt seat. Later I transitioned to showing pigeons, dogs, and goats. I have experience in almost all livestock species and many companion animal species.

Artifacts, Issue 22,

cwp.missouri.edu

their two-year-old year and progress to 6 or 7 furlongs by the summer of that year (Dooley, 2024). Following their juvenile year, horses may specialize in different race distances, such as sprinters for races between 5 and 7 furlongs, milers between 7 and 9 furlongs, middle distance or classical runners between 9 and 14 furlongs, and stayers for races spanning 12 to 20 furlongs (Dooley, 2024). Horses that train over National Hunt jumps for hurdles and steeplechases will run even long distances ranging from 16 to 36 furlongs (Dooley, 2024). Races greater than 1671 meters or 8 furlongs have a higher rate of horses failing to finish compared to races under 1200 meters or 6 furlongs in length (Tanner et al., 2016). The correlation between increased race length and failing to finish, it is crucial to tailor the training and veterinary care to mitigate injuries and improve peak performance.

The standard starting gate in the United States allows for 14 horses to start in a race, while some older starting gate models only accommodate 12 starters (Frakes, 2019). Auxiliary gates can further increase the number of starters to 20 as seen in the Kentucky Derby (Frakes, 2019). Races with larger field sizes tend to have a higher rate of failure to finish compared to those with smaller field sizes (Tanner, et al., 2016). While many criticize the use of the 20-horse starting gate, Darren Rogers, a senior director of communications and media services at Churchill Downs stated, “Every element of a race — from the start to the finish — is a safety concern, but we just don’t believe reducing the size of the Derby field to any specific number will eliminate the inherent risk that comes with competition” (Frakes, 2019). There was no correlation between gate position and an increased risk of failing to finish a race (Tanner et al., 2016). Racing poses inherent risks for injuries and breakdowns, but larger field sizes may lead to increased negative outcomes compared to smaller fields.

Track composition and condition affect the rate of failure to finish due to injury, with horses racing on turf tracks being at a lower risk for breakdowns compared to those on dirt tracks (Mohammed et al., 1991). Muddy or sloppy dirt tracks do not result in an increase in breakdowns compared to normal or good dirt tracks (Mohammed et al., 1991). Firmer turf tracks increase the likelihood of breakdowns (Rosanowski et al., 2018). In jump racing, increased firmness of the track is associated with a higher rate of tendon injury (Reardon et al., 2012). Weather and season also impact track conditions and the rate of injury and breakdown, with horses being more likely to break down during the summer months compared to the spring and winter (Mohammed et al., 1991). On synthetic tracks, sustained high temperatures can cause the wax coating to begin to melt, resulting in poorer performance and potentially a higher risk of injury (Peterson et al., 2010). During summer and fall months, turf and synthetic all-weather tracks have the highest risk of fatalities (Rosanowski et al., 2018). Jumps racing showed similar results with horses racing during the summer season being more likely to develop tendon injuries compared to all other seasons (Reardon et al., 2012). The influence of track conditions and weather highlight the need for track maintenance and monitoring to reduce the potential for breakdowns.

The average starts per horse in 2017 was 6.15, a 38.5% decrease from 1976 (Mitchell and Angst, 2018). Horses in higher class levels experienced a greater decrease in starts per year, averaging 5.5 starts in 2017, compared to 8.5 starts in the lowest class levels (Mitchell and Angst, 2018). However, horses that start in more races per year are less likely to experience breakdowns (Mohammed et al., 1991). Horses racing between seven and twelve times per year have a lower rate of breakdowns than those that make six or fewer starts (Mohammed et al., 1991). Additionally, horses are less likely to experience breakdowns after their first racing season; horses racing past their fifth season are 100 times less likely to break down compared to horses in their first season (Mohammed et al., 1991). With so many contributing factors to breakdowns and failure to finish races, it is no wonder that the issue does not have a clear-cut solution.

Human Safety

While horse safety is at the forefront of the general public’s minds, human safety is often overlooked until a tragic accident occurs. On February 1, exercise rider Arturo Mares died from injuries he sustained after falling from his mount while working at Santa Anita Park in Arcadia, California (BloodHorse, 2024). An average of two jockeys each

year suffer the same fate as Mares (Ross, 2019). Injuries resulting from kicks and bites, poor working conditions, alcohol and drug abuse, and nutrient deficiencies are also major issues within the sport (Stallones et al., 2023). The most common reasons for injury to jockeys are becoming unseated from their mount during a race and horses falling (Press et al., 1995). Jump racing has a higher rate of falls, but flat racing has a higher incidence of injury (O'Connor et al., 2017). There was a significant increase in jockey injuries between 2006 and 2015 (O'Connor et al., 2017). Soft tissue injuries and fractures are the primary injuries reported by jockeys, with upper limb injuries being more common in jump racing and lower limb injuries being more common in flat racing (O'Connor et al., 2017). Inexperienced riders are more likely to fall during a race (Tanner et al., 2016). Falls decrease with experience, though amateur jockeys still average 134.77 falls per 1000 rides with 67.4 injuries per 1000 falls (O'Connor et al., 2018).

Jockeys are required to meet a weight standard to be allowed to race and must often undergo rapid weight loss to meet such requirements (McGuane et al., 2019). In Ireland, jockeys must be between 52.7 to 64 kilograms, or 116 to 141 pounds, including the weight of their tack to race, which is well below most people's normal weight range (Cullen et al., 2015). Despite the devastating effects on mental health, jockeys use food restriction, dehydration, and occasionally drug abuse to manage their weight (McGuane, 2019). The more weight jockeys lose, the more negative their mood and disordered their eating becomes (Cullen et al., 2015). Common mental health disorders, including anxiety, depression, and alcoholism, are very common among jockeys with 79% reporting symptoms of one or more disorders (King et al., 2021a). Mental and physical health resources are vital to assist jockeys in developing healthy strategies to maintain their riding weight and protect their mental health.

Jockeys are not the only ones at risk of mental health disorders, trainers and stable staff are also at risk. Trainers often face financial stress, long working hours, and social isolation, which leads to 45% of trainers meeting the diagnostic criteria for one or more mental health disorders (King et al., 2021b). Stable staff also suffer from mental health disorders, especially after suffering an injury, due to concern over their employment and injury (Davies et al., 2023). Staff who experienced anxiety and depression after an injury were more likely to not report future injuries and take time off (Davies et al., 2023). Increased accessibility to health resources would benefit trainers and stable staff to mitigate critical mental health issues and aid in coping with injuries sustained while working with horses.

Safety Devices

New technology is always being developed to mitigate and avoid incidents on the track. StrideSafe is a sensor system designed to detect potential injuries based on abnormalities in the horse's gait that are attached to the saddle cloth of a racehorse (Voss, 2023). During a trial period in New York, the system demonstrated a 90% accuracy rate in predicting fatal injuries (Voss, 2023). The system has also been implemented at Churchill Downs in Louisville, Kentucky, where horses with abnormalities detected underwent a PET scan that often found bony changes that indicated a condylar fracture may be imminent (Voss, 2023). Condylar fractures are a fracture that occurs above the fetlock in the cannon bone, which is similar to the bones in the back of a human's hand, due to repetitive strain (Palm Beach Equine Clinic, 2018). The implementation has allowed tracks to predict injuries before they occur, which can be used to prevent future breakdowns and better focus veterinary care to treat current injuries.

Turf analysis and management are utilized to predict and mitigate possible injuries by assessing the condition of a racing surface (Schmitt et al., 2024). Various devices measure the surface's ability to allow a horse's hooves to penetrate and gain traction while also resisting divot formation (Schmitt et al., 2024). The Orono Biomechanical Surface Tester (OBST) is the international standard for surface testing, despite its limitations due to the complexity of its operation (Schmitt et al., 2024). Other simpler options for testing the racing surface include moisture probes, the Clegg Impact Hammer (CIH), Longchamp Penetrometer (LP), Turf Shear Tester (TST), and the GoingStick® (GS) (Schmitt et al., 2024). The LP has the best ability to predict horse performance and injury, followed by the CIH, and then the moisture probe (Schmitt et al., 2024). The TST and GS are not recommended as their data does not represent the OBST data well (Schmitt et al., 2024). Data gathered by these devices are used to determine if a track is suitable for

racing (Schmitt et al., 2024). Turf analysis tools can be used to indicate if the track is unsafe for racing to prevent injuries influenced by weather and track conditions.

Online reporting systems have also been used to track and reduce injuries, with vast improvements in reporting accuracy and efficiency compared to the previous paper-based system (Gibson et al., 2022). Since the implementation of the online reporting system, there has been an increase in the rate of non-incident examinations being performed, while clinical findings, the rate of injuries, have remained constant (Gibson et al., 2022). These non-incident examinations are a useful tool for monitoring risk factors associated with injuries (Gibson et al., 2022). The reporting system has found that most reported fatalities are attributed to irreparable fractures with horses racing more than 1600 meters have a 1.7 times higher risk of such fractures compared to those racing less than 1600 meters (Gibson et al., 2023). Reporting also found that the risk of fractures is higher in male horses and in horses racing on firmer track surfaces (Gibson et al., 2023). Additionally, horses older than five were found to be twice as likely to experience cardiac failure (Gibson et al., 2023). Reporting system provide a centralized way to track risk factors that can be used to target veterinary intervention and track maintenance.

Current Regulations

Regulations in horse racing often receive both criticism and praise as they strive to satisfy trainers and fans alike. Reporting of injuries and fatalities associated with racing must be submitted within 72 hours by a veterinary official to the Jockey Club's Equine Injury Database (EID); however, not all tracks choose to make their statistics available to the general public (The Jockey Club, 2023). Since the implementation of the EID in 2008, there has been a decrease in the rate of fatalities from 2.00 to 1.32 equine fatalities per 1000 starts (The Jockey Club, 2024). The use of reporting systems has allowed racing professional to decrease the rate of fatalities by targeting intervention methods to improve the safety of horses and jockeys.

The Horse Racing and Integrity Authority (HISA), another national authority created to regulate horse racing safety, was approved by the Federal Trade Commission in July 2022 (HISA, 2023). HISA requires its affiliated tracks to establish a Racetrack Safety and Welfare Committee tasked with investigating every injury, fatality, and safety concern related to the track (HISA, 2023). In each jurisdiction, HISA has appointed a medical director who oversees all human injuries and a lead veterinarian who inspects and treats horses (HISA, 2023). The lead veterinarian is also responsible for anti-doping testing and emergency medical care in the event of an injury (HISA, 2023). Investigations into injuries and fatalities by trained professionals can ensure that proper safety measures are enacted to prevent similar occurrences from happening in the future.

Racetracks can also enact their own rules, as Churchill Downs did after a string of injuries that resulted in twelve equine fatalities during their summer meet in 2023 (Finley, 2023). Churchill Downs removed the purse pay-outs to horses finishing out of the top five, restricted the number of starts a horse can make in a rolling eight-week period, and enacted ineligibility standards for poor performance (Finley, 2023). Despite Churchill Downs' claim that these rules were implemented to reduce breakdowns, they would have only applied to one of the twelve horses that died during the meet (Finley, 2023). Although regulations are designed with the safety of horses and jockeys in mind, they are not always well-received when put in practice.

Public Opinion

Horsemen are split on the current regulations imposed on the sport, with some claiming that they are some of the worst rules they have ever seen while others believe that they are in the best interests of the horse (Louis and Bartelli, 2024). Due to Churchill Downs' ineligibility standards for poor performance, horsemen worry that it will incentivize jockeys to push tired horses to prevent them from becoming ineligible to race (Louis and Bartelli, 2024). However, others support restricting starts and having ineligibility standards in place because it protects the horse from racing when it is injured or not able to compete at the level of competition it is entered (Lous and Bartelli, 2024).

HISA regulations also come under fire from horsemen, with some believing that they are too restrictive and are a form of the government overstepping their boundaries (Louis and Bartelli, 2024). While anti-doping regulations are supported by the public, many feel that HISA regulations are overly restrictive regarding the medications permitted for racehorses and harshly punish those with minimal violations that could be caused by contamination (Louis and Bartelli, 2024). Many believe that HISA would be better accepted among horsemen if it were run by individuals with experience in the horse racing industry rather than government officials (Louis and Bartelli, 2024). While regulations based on scientific data can help reduce injuries and increase support from the general public, they may conflict with the opinions and traditions of seasoned horsemen.

Recommendation

Horse racing regulations need to balance the longstanding traditions of the industry with science-based data surrounding injuries, fatalities, and the well-being of horses and people. Incidents of injuries and fatalities associated with tracks should be reported, and investigations should be conducted afterward to determine their causes. The use of technology to detect potential hazards and subtle changes that may lead to injury could significantly improve the prediction and prevention of injuries on the track. If a detection device identifies a horse as at risk for injury, it should undergo an examination by a veterinarian to determine its soundness for racing. Additional factors that should be monitored include the horse's age, racing experience, and past performance.

Restricting the starts a horse can make within a period of time conflicts with studies that observe a decrease in injuries with an increase in the number of starts a horse makes. Additionally, such restrictions reduce opportunities for apprentice jockeys to gain experience, thereby increasing their likelihood of sustaining injuries due to a lack of experience. However, if a horse consistently performs poorly, it should be closely monitored for potential injuries. Poor performance restrictions are supported by evidence that poor performance can be indicative of injury.

There should be resources made available for jockeys, trainers, and stable staff to receive mental health care and medical attention in the event of a crisis. Considering the high rate of injuries in the sport, it is important for medical staff to thoroughly assess a jockey's fitness to race prior to starting in a race. Mental health services should be available to reduce the incidence of anxiety, depression, distress, and drug abuse. To alleviate financial stress and improve the mental health of jockeys, trainers, and stable staff associated with horses outside the top five, purse payouts should not be restricted to the top finishers.

Regulations must take into account the opinions of experienced horsemen and utilize modern technology to create a safe environment for horses and people. There should be a uniform standard across the country with the ability to further restrict the usage of medications, training techniques, and performance standards at the state and track level to account for local opinion and traditions.

References

BloodHorse. 2024. Exercise rider Mares dies five days after accident. Available at: https://www.bloodhorse.com/horse-racing/articles/274816/exercise-rider-mares-dies-five-days-after-accident Accessed: February 20, 2024.

Bull, A. 2023. Horses: $122 billion annually to the US economy. Available at: https://www.twinspires.com/edge/racing/horses-dollar122-billion-annually-to-the-us-economoy/ Accessed: February 20, 2024.

Cullen, S., E. Dolan, A. McGoldrick, K. O'Brien, B. P. Carson, and G. Warrington. 2015. The impact of making-weight on cognitive performance in apprentice jockeys. J. Sports Sci. 33(15):1589-1595.

Davies, E., S. Liddiard, W. J. McConn-Palfreyman, J. K. Parker, L. J. Cameron, and J. M. Williams. 2023. Anxiety and depression in British horseracing stud and stable staff following occupational injury. Animals. 13(21):3337.

Dooley, J. 2024. How long is a horse race? Available at: https://www.britishracecourses.org/how-long-is-a-horse-race/ Accessed: March 12, 2024.

Finley, B. 2023. Churchill Downs unveils new safety initiatives. Available at: https://www.thoroughbreddailynews.com/new-safety-initiatives-at-churchill-downs/ Accessed: February 20, 2024.

Frakes, J. 2019. Is it time for the Kentucky Derby to stop running 20 horses? Available at: https://www.courier-journal.com/story/sports/horses/kentucky-derby/2019/05/10/kentucky-derby-20-horses-too-many-race/1128243001/ Accessed: March 12, 2024.

Gibson, M. J., K. A. Legg, E. K. Gee, and C. W. Rogers. 2022. Race-level reporting of incidents using an online system during three seasons (2019/2020–2021/2022) of Thoroughbred flat racing in New Zealand. Animals. 12(21):1-14.

Gibson, M. J., K. A. Legg, E. K. Gee, and C. W. Rogers. 2023. The reporting of racehorse fatalities in New Zealand Thoroughbred flat racing in the 2011/12–2021/22 seasons. Animals. 13(4):1-12.

Gramm, M. and R. Marksteiner. 2010. The effect of age on Thoroughbred racing performance. J. Equine Sci. 21(4):73–78.

Hegarty, M. 2023. Racing officials consider postponing Saratoga's Sunday card following two more breakdowns. Available at: https://www.drf.com/news/racing-officials-consider-postponing-saratogas-sunday-card-following-two-more-breakdowns Accessed: February 20, 2024.

HISA. 2023. Regulations. Available at: https://hisaus.org/regulations#racetrack-safety-program-(rule-series-2000) Accessed: February 20, 2024.

King, L., S. J. Cullen, S. O'Connor, A. McGoldrick, J. Pugh, G. Warrington, G. Woods, A. M. Nevill, and C. Losty. 2021. Common mental disorders among Irish jockeys: Prevalence and risk factors. The Physician and Sportsmedicine. 49(2):207-213.

King, L., S. J. Cullen, S. O'Connor, A. McGoldrick, J. Pugh, G. Warrington, and C. Losty. 2021. Racehorse trainer mental health: Prevalence and risk factors. J. Equine Vet. Sci. 101:103423.

Louis, D. and J. Bartelli. 2024. Personal communication. Zoom.

McGuane, T., S. Shannon, L. Sharp, M. Dempster, and G. Breslin. 2019. “You wanna ride, then you waste”: The psychological impact of wasting in National Hunt jockeys. The Sport Psychologist. 33(2):129-136.

Mitchell, E. and F. Angst. 2018. Starts by U.S. horses continue downward trend. Available at: https://www.bloodhorse.com/horse-racing/articles/229928/starts-by-u-s-horses-continue-downward-trend Accessed: March 14, 2024.

Mohammed, H. O., T. Hill, and J. Lowe. 1991. Risk factors associated with injuries in Thoroughbred horses. Equine Vet. J. 23(6):397-484.

O’Connor, S., G. Warrington, A. McGoldrick, and S. Cullen. 2017. Epidemiology of injury due to race-day jockey falls in professional flat and jump horse racing in Ireland, 2011-2015. J. Athletic Training. 52(12):1140-1146.

O’Connor, S., G. Warrington, A. McGoldrick, and S. Cullen. 2018. A 9-year epidemiologic study (2007-2015) on race-day jockey fall and injury incidence in amateur Irish horse racing. J. Athletic Training. 53(10):950-955.

Palm Beach Equine Clinic. 2018. Condylar fracture: Your horse’s career isn’t over! Available at: https://equineclinic.com/medical/surgery-medical/condylar-fracture/ Accessed: April 10, 2024

Peterson M. L., R. F. Reiser, P. H. Kuo, D. W. Radford, and C. W. McIlwraith. 2010. Effect of temperature on race times on a synthetic surface. Equine Vet. J. 42(4):351-7.

Press, J. M., P. D. Davis, S. L. Wiesner, A. Heinemann, P. Semik, and R. G. Addison. 1995. The national jockey injury study: An analysis of injuries to professional horse-racing jockeys. Clinical J. Sport Med. 5(4):236-40.

Reardon R. J. M., L. A. Boden, D. J. Mellor, S. Love, J. R. Newton, A. J. Stirk, and T. D. H. Parkin. 2012. Risk factors for superficial digital flexor tendinopathy in Thoroughbred racehorses in steeplechase starts in the United Kingdom (2001–2009). The Vet. J. 195(3):325-330.

Rosanowski, S. M., Y. Chang, A. J. Stirk, and K. L. P. Verheyen. 2018. Risk factors for race-day fatality in flat racing Thoroughbreds in Great Britain (2000 to 2013). PLoS ONE. 13(3):1-12.

Ross, D. 2019. Jockey health and safety: Necessary advances benefit all of industry. Available at: https://www.thoroughbreddailynews.com/jockey-health-and-safety-necessary-advances-benefit-all-of-industry/ Accessed: March 14, 2024.

Saratoga Race Course. 2024. Glossary of racing terms. Available at: https://www.saratogaracetrack.com/about-horse-racing/glossary-racing-terms/b/#:~:text=breakdown%3A%20When%20a%20horse%20suffers,race%20of%20her%2Fhis%20career. Accessed: April 10, 2024.

Schmitt, R. R., W. Sanderson, J. Rogers III, T. J. Barzee, and M. Peterson. 2024. A comparison of devices for race day characterization of North American turfgrass Thoroughbred racing surfaces. Animals. 14(1):1-14.

Stallones, L., P. McManus, and P. McGreevy. 2023. Sustainability and the Thoroughbred breeding and racing industries: An enhanced one welfare perspective. Animals. 13(3):490.

Tanner, J., C. Rogers, C. Bolwell, N. Cogger, E. Gee, and W. Mcllwraith. 2016. Analysis of failure to finish a race in a cohort of Thoroughbred racehorses in New Zealand. Animals. 6(6):1-11.

The Jockey Club. 2023. EID participating tracks. Available at: https://jockeyclub.com/default.asp?section=Advocacy&area=11 Accessed: March 18, 2024.

The Jockey Club. 2024. Equine injury database. Available at: https://jockeyclub.com/default.asp?section=Advocacy&area=10 Accessed: March 18, 2024.

Voss, N. 2023. Multiple tech systems being tested to help prevent racehorse injury. Available at: https://paulickreport.com/horse-care-category/multiple-tech-systems-being-tested-to-help-prevent-racehorse-injury Accessed: February 20, 2023.