

Using quantitative methods to understand how dairy farmer wellbeing connects to farm management, barn design, technology, and animal welfare.

by

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ABSTRACT

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The agricultural profession, particularly dairy farming, is known for its demanding nature, both physically and mentally. Dairy farmers encounter various challenges including long working hours, physical labour, financial pressures, and unpredictable weather conditions. My objective was to explore different farm management practices, farming factors, and the prevalence of mental and physical health issues among dairy farmers in Western Canada and Ontario. Statistical analyses included t-tests, ANOVA, and chi-squared tests to compare means with general population averages and to investigate associations between mental health scores and physical health outcomes with survey variables. The results of the survey indicated that farmers (n=115) scored significantly higher on perceived stress ($P<0.001$), anxiety ($P<0.001$), depression ($P=0.04$), and resilience scales ($P<0.001$) compared to the general population. The results also highlighted concerns regarding the physical health of dairy farmers, with the majority reporting work-related injuries and health issues. I identified significant differences when comparing mental and physical health with work-life balance, social environment and support, and specific dairy-related stressors. Farmers faced both personal and farming-related financial stressors. Surprisingly, health outcomes did not differ based on housing or milking system, management practices, farm responsibilities, or financial and transition planning variables. Therefore, dairy farmers appear to have similar well-being in different production systems, but farm finance, feed cost, weather, and workload constraints are major stressors. I then adopted a more holistic approach to cluster farmers based on their well-being and farm management. The analysis identified four distinct groups of dairy farmers based on their survey responses. It also emphasized the need for a deeper understanding of the unique challenges faced by individual farmers in their production systems. Without this understanding, there is a risk of developing intervention plans that are ineffective or inappropriate for the Canadian dairy industry. The typologies developed in this research offer a promising foundation for providing tailored support resources.

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Finally, I want to dedicate this research to all the dairy farmers who have been impacted by the topic of this study. My goal is for this work to help further knowledge and understanding in this area and, ultimately, to bring about positive change and progress.

CONTRIBUTION OF AUTHORS

Halimatou Tambadou: Conceptualization, Methodology, Data Collection, Data Analysis, Writing (original draft), and Writing (review and editing). **Meagan King:** Conceptualization, Methodology, Data collection, Data Analysis, Writing (original draft), Writing (review and editing), and Supervision. **Charlotte Winder, Briana Hagen, Kees Plaizier:** Conceptualization, Methodology, Data Analysis, and Writing (review and editing). **Breanna Zwick and Arielle Le Heiget:** Conceptualization, Methodology, Data collection. **Kim Ominski, Ed Pajor, Andria Jones, Jolene Kinley, and Heather Watson:** Conceptualization, Methodology. **Gabriel Dallago:** Data Analysis

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CHAPTER 1 | Literature Review and Research Objectives

1.1 Introduction

One Health is an interdisciplinary collaborative approach to solving complex health problems, recognizing the inherent interdependence of human, animal, and ecosystem health (World Health Organization, 2023). Although the One Health framework has been increasingly adopted, it is still primarily applied to people (Broom, 2022; Pinillos et al., 2016). Further, there is a need to develop a moral and ethical framework that encompasses well-being and environmental integrity beyond health and the absence of disease. One Welfare, a concept built on the foundation of One Health, is a powerful tool to recognize the many social interconnections between human well-being, animal welfare, and the integrity of the physical and social environment (Pinillos et al., 2016). Therefore, One Welfare is a call for coordinated actions to improve the well-being of human and non-human animals as well as that of the environment.

The One Welfare framework can be used to examine the Canadian dairy sector, which is a complex and diverse system that operates under a supply management system. This system is based on planned domestic production, administered pricing, and dairy product import controls (Government of Canada, 2021). Additionally, the Canadian dairy industry is sustained by the tireless efforts of dairy farmers. Before dairy products can make it to store shelves, farmers must navigate a range of challenges, including management decisions, animal health and welfare, and milk production and quality (Medeiros et al., 2022). These factors are unique to the dairy farming industry and contribute to the numerous and unpredictable occupational stressors that mark the life of a dairy farmer (Contzen & Häberli, 2021). Unfortunately, farmers also face the challenge of mental well-being stigma, particularly in rural areas, which further compounds the pressure of dairy farm management (Contzen & Häberli, 2021; Polain et al., 2011; Wilton, 2019). As such, it is crucial to examine the uncertainty and limited control that farmers have over various sector-specific elements that can negatively impact their well-being. In this case, the concept of One Welfare is well-suited for understanding the intricate interactions among dairy farmers, cows, and farm management.

1.2 Dairy farmer well-being and farming stressors

Few researchers have explored associations between animal welfare, farm management and the well-being of farmers. Findings indicate that many farmers experience high levels of psychological distress and mental health issues (Khan et al., 2022) in comparison to individuals in other professions. Numerous researchers have underscored this concern, emphasizing the need for support and resources to address the mental health challenges faced by farmers (Hagen et al., 2021; Jones-Bitton et al., 2020; King et al., 2021; Rudolphi et al., 2020; Torske et al., 2016). Farmers in the United Kingdom (UK), United States (US), Australia, Finland, and Norway have also reported high levels of stress (Booth & Lloyd, 2000; Fraser et al., 2005; Walker & Walker, 1988), anxiety (Sanne et al., 2004), depression (Elliot et al., 1995; Torske et al., 2016), and psychological distress (Brumby et al., 2012), the latter being defined as a state of emotional suffering characterized by symptoms of stress, depression, and anxiety (Viertiö et al., 2021).

Researchers have shown that proper management practices and the incorporation of new technologies such as automatic milking systems have the potential to increase milk production, to reduce labour, to allow for detailed monitoring of the health and productivity of individual animals, and to enhance the welfare of dairy cows (Jacobs & Siegford, 2012; Tse et al., 2018; Ventura et al., 2021). However, most previous studies have been focused on farm management, the health and welfare of dairy cattle (Karttunen et al., 2016), and the economics of milk production (Jacobs & Siegford, 2012; Lyons et al., 2014; Oudshoorn et al., 2012; Steeneveld et al., 2012), whereas less focus has been placed on farmers' well-being.

1.2.1 Farming stressors

Farmers often feel isolated due to working in remote areas, leading to loneliness and reluctance to seek help because that involves admitting their feelings of loneliness and stress (Hammersley et al., 2021; Judd et al., 2006). This is compounded by the stigma of mental health in the agricultural sector, the lack of supplemental health care for farmers beyond basic provincial coverage, the lower availability of mental health services in rural communities, and the cost and stress associated with seeking help (Judd et al., 2006; Meer, 2004). In addition, the public often scrutinizes farmers, and this creates a feeling of disconnect between the public's perception of farming and the

experience of farmers (Contzen & Häberli, 2021). Many farmers feel that their occupation needs to be properly understood and valued by the public and the industry such as the provincial dairy milk boards (Finnigan, 2019). The lack of understanding leads to distress, particularly when the integrity of farmers is questioned. Activist groups leverage social media to increase pressure by criticizing livestock producers and advocating for the highest welfare standards, regardless of whether those conditions are met by producers. This is recognized as a growing concern in Canada (Finnigan, 2019).

Agriculture, in general, is an industry fraught with uncertainties and limited control over sector-specific factors (Karasek, 1979). Financial challenges such as debt, loan restrictions, access to finance, and succession, among others, are significant stressors for farmers (Finnigan, 2019; Meuwissen et al., 2019). Additionally, economic uncertainties, such as loan restrictions and high interest rates, exacerbate these challenges (Finnigan, 2019). According to a study of Canadian farmers by Walker and Walker (1988), both men and women in farming were most stressed about finances, geographical isolation, and finding and retaining reliable employees. The Canadian Association for Farm Safety (2005) conducted a cross-sectional survey that found poor production, government policies, and farm finances were the top farming stressors. In Manitoba, Sturgeon and Morrisette (2010) found that financial strain and a lack of control over farming variables such as weather, family stress, farm culture, and social isolation were the main stressors in farming. Climate change and extreme weather events - such as droughts, floods, wildfires, and disease outbreaks - put crops at risk and financially stress the industry (Abbas et al., 2022; Rocha et al., 2022). Financial difficulties can cause a great deal of stress, potentially leading to anxiety and depression (Kato et al., 2022). Additionally, decision-makers may also have to deal with increased financial pressure to ensure sustained financial management and managerial responsibilities, contributing to their mental well-being concerns.

Researchers have demonstrated that certain agricultural commodity groups have higher stress levels, with dairy farming being considered one of the most stressful commodities to farm (Brennan et al., 2022; Lunner Kolstrup et al., 2013). Kato et al. (2022) found that dairy farm managers in Japan face a higher risk of experiencing poor mental well-being due to various challenges that come with running a business. These factors include animal disease, weather, policies and regulations, and economic fluctuations (Finnigan, 2019). In the dairy industry,

maintaining high milk quality is a top priority, and this requires careful consideration of managing feed and metabolic health of cows. As noted by Kurihara & Shimoura (2008), maintaining dairy cow hygiene is also crucial to prevent infections and maintain udder cleanliness and health, which can impact milk quality if the udders and teats get contaminated by pathogenic bacteria. However, achieving these goals requires significant physical and mental effort from dairy farmers, which can take a toll on their well-being. Dairy farmers face a unique set of challenges that require them to juggle multiple responsibilities simultaneously. They must maintain a healthy financial standing to ensure the sustainability of their business while providing an adequate housing environment for their cows and upholding high milk quality standards (Kato et al., 2022). As a result, implementing optimum techniques to manage farming systems requires considerable effort and numerous sacrifices, which may increase stress, depression, and anxiety for dairy farmers.

1.2.2 Mental Well-being: mental health and beyond

The idea of mental well-being has evolved in response to advancements in fields such as psychology, sociology, and public health (Gautam et al., 2024). Initially, the emphasis was on mental illness, with a focus on identifying and addressing issues, which often took priority over mental well-being. However, in recent years, there has been a shift towards a more holistic and positive approach to mental health (Gautam et al., 2024). Well-being, however, is outside the medical model of health, as it is not a diagnostic concept (Schramme, 2023). Defining well-being is essential for comprehending and discussing mental health, but it has been the subject of much debate. It is widely acknowledged that subjective well-being varies significantly among individuals, as do the influencing factors (Gautam et al., 2024). Indeed, the term "mental well-being" can sometimes be unclear, as it may or may not imply the absence of mental illness or distress (Gautam et al., 2024). Mental well-being is characterized by optimal physical and behavioural health, sense of purpose in life, active participation in enjoyable work and leisure activities, positive relationships, satisfaction, and contentment (Gautam et al., 2024).

Mental health and mental well-being are distinct concepts. Poor mental health or mental disorders are marked by atypical psychological patterns, emotional distress, and impaired functioning (Prince et al., 2007; WHO, 2022), whereas mental well-being can change with the phases of mental

illnesses (Prince et al., 2007; Weich et al., 2011; WHO, 2022), which often involve relapses and periods of improvement. The frequency and duration of relapses may impact the fluctuation in mental well-being (Weich et al., 2011). This definition of mental well-being closely relates to the World Health Organization’s (WHO) comprehensive and positive definition of health. The WHO defines mental health as "a state of well-being in which an individual realizes [their] own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to [their] community." This definition also resonates with the positive psychology approach advocated by Martin Seligman (2011), who proposed PERMA as a model of psychological well-being (Figure 1; Seligman, 2011).

Positive emotion	Create and cultivate positive feelings and experience.
Engagement	Participate in activities that create a sensation of flow and absorption.
Relationships	Develop meaningful and positive relationships with others.
Meaning	Discover one’s life’s purpose and importance.
Accomplishments	Achieve goals and accomplishments that contribute to a sense of competence and mastery.

Figure 1. Five core elements of psychological Seligman’s PERMA model of well-being.

Previously, researchers have examined farmer mental health by assessing resilience, anxiety, stress, and depression (Jones-Bitton et al., 2020; King et al., 2021). However, the conceptualization of mental health needs to go beyond the traditional definition of mental health, and it needs to be included in well-being, which is a larger framework that encompasses life satisfaction and success across various domains, including professional, personal, and interpersonal spheres (Jarden & Roache, 2023). Other aspects of well-being also include social support (Huppert, 2009) and occupational well-being (Diener et al., 2017).

1.2.1.1 Sense of control and financial stability

Life is often filled with unexpected events and difficulties that can lead to feelings of being overwhelmed and stressed. Feeling a sense of control over our lives is a key component of mental well-being (WHO, 2022). Routines help us navigate our days with a clear plan, reducing stress, anxiety and providing a strong foundation to handle whatever comes our way (Hirsh et al., 2012). This increased sense of control can help improve overall well-being and mental stability (Rodin, 1989; Taylor et al., 1988).

Being in a good financial state also contributes to good mental health. Debt and financial problems can lead to poor mental health, such as chronic and long-lasting stress (Turunen & Hiilamo, 2014). Financial problems may result in physical health issues, like migraines, a compromised immune system, elevated blood pressure, gastrointestinal problems, and sleep disturbances (Salleh, 2008; WHO, 2022). It can lead to spending money to treat these issues, which in turn can lead to more financial stress. Studies on finances and mental well-being showed that debt is positively correlated with depression (Bialowolski et al., 2021). Additionally, debt-related financial distress was shown to be an independent predictor of depression, associated with 51% increased odds of subsequent onset of depression (Bialowolski et al., 2021). There is also evidence on the adverse effects of indebtedness on self-reported anxiety (Drentea, 2000) and the ability to meet monthly expenses may be protective against diagnosed anxiety (Bialowolski et al., 2021). Israel et al. (2014) also found evidence of a negative association between credit scores and cardiovascular disease. Therefore, there are many associations between financial, mental, and physical well-being.

In the past, researchers have suggested that individuals experiencing job-related stress could be at a greater risk of mental health issues such as depression (Yoshizawa et al., 2016). This was particularly evident during COVID-19, where it was observed that depression among employees was closely linked to workplace stressors (Gao et al., 2012). In summary, the connection between well-being outcomes and occupational stress has been established, and there is a need to explore the underlying mechanisms further.

1.2.3 Physical well-being

Dairy farming has been widely recognized as having a high potential for physical harm to workers (Doughrate et al., 2009; Rautiainen & Reynolds, 2002). Surveillance data on worker injuries and fatalities often lack the necessary details to explain why injuries occur in dairy operations, and there is limited research specifically addressing injuries and fatalities associated with handling livestock on dairy farms (Doughrate et al., 2009). Additionally, in the agricultural sector, underreporting of worker injuries is widespread (Donham & Thelin, 2006). There are various potential dangers in the workplace on dairy farms, depending on the specific tasks being carried out. Examples of these hazards include machinery, confined spaces, handling livestock, and pesticides. Researchers in the US have identified dairy farming as having one of the highest risks of injuries among all US agricultural groups (Boyle et al., 1997; Mac Crawford et al., 1998). A study by Mitloehner and Calvo (2008) shows that machinery and interactions with animals are the two main causes of injuries to workers (both fatal and nonfatal). Incidents involving machinery include tractor rollovers and entanglement in rotating shafts. Animal-related injuries include kicks, bites, and being pinned between animals and fixed structures. Other causes of injuries include chemical hazards, confined spaces (e.g., manure lagoons), use of power tools, and improper use or lack of personal protective equipment (Mitloehner & Calvo, 2008).

In a study of dairy farm claims in Australia, Fragar et al. (2006) reported an incidence rate of 2.8 per 100 workers and that most incident claims in the dairy industry were made by men (4 out of 5). Between 2001 and 2003, tractor incidents accounted for 2.8% of claims, while 10% were related to motorcycles, including all-terrain vehicles. Motorcycle injuries mostly affected legs and resulted in fractures (35%) and sprains (25%). Cattle caused at least 24% of injuries in the dairy industry, mostly affecting the arms, especially the hands and fingers, and resulting in fractures (40%) and sprains/strains (30%). The main causes of dairy-related injuries were slips, trips, and falls, affecting workers in both indoor and outdoor environments, resulting in sprains (nearly 50%) and fractures (29%) (Fragar et al., 2006).

Another study conducted in Sweden (Pinzke & Lundqvist, 2007) was designed to gain a comprehensive understanding about the source and scope of agricultural injuries. Researchers determined that around 5,000 incidents of injury took place on Swedish farms in one year (2004).

Roughly 70% of these injuries occurred on livestock operations, and within this category, 30% were related to dairy farms (i.e., 21% of all farm injuries occurred on dairies). The majority of injuries occurred during activities such as milking, handling, and moving animals (particularly injuries caused by animal kicks, stepping on, striking, and crushing). Falls (e.g., slipping or tripping) were relatively common during tasks such as milking, manure handling, stall cleaning, and feeding.

1.3 Farm responsibilities, social support, and work-life balance

1.3.1 Farm responsibilities and work-life balance

Dairy farming in general is hard work that involves long hours, physical labour, and responsibility for animals. Chores include milking, feeding, cleaning, and managing cows' health. Farmers also need to manage the farm's finances, keep track of records for food safety programs, and hire and manage employees. While technology and automation have assisted dairy farmers, many tasks still need to be manually done by dairy farmers while following safety protocols.

In today's rapidly changing world, achieving stability and balance can often seem challenging. Dairy farmers start their day very early by tending to their animals. They milk, feed, and care for animals to ensure their productivity and health. After completing morning tasks, farmers attend to other chores, such as cleaning the barn alleys and stalls. Depending on the season, they grow their feed and do fieldwork between milking times. The daily ration for the cows must also be prepared, and they must be milked and fed again. Even after their tasks are done, the farmers must observe and assist in calving as needed at night. All these responsibilities make it very difficult for farmers to have time off or time to rest during the day. Statistics Canada reported that most operators (80.7%) work more than 40 hours a week on average on the farm. A survey by the Canadian Agricultural Human Resource Council found that 52% of dairy producers considered long working hours a significant issue (CAHRC, 2019). Farmers' work hours can vary significantly depending on the season. As such, leaving the farm for even a brief period can be a daunting task. Dairy farmers must adhere to a 24/7 mentality and responsibility towards their animals. They sacrifice their free time and flexibility to ensure the well-being of their animals (Schuppli et al., 2023). Even

when working with family members or trusted employees, they experience a sense of guilt when they take a break from the farm (Roy et al., 2017). This deep sense of responsibility towards their chores and animals drives them to always be present on the farm. Working long hours may also result in sleep deprivation, which can further affect well-being (Bannai & Tamakoshi, 2014). In a study of 700,000 people across occupations, Kivimäki et al. (2015) found a strong correlation between extended working hours and the increased risk of health issues, particularly among individuals in lower socioeconomic status groups. People who worked 55 hours or more per week were found to be 13% more likely to experience a heart attack and 33% more likely to suffer a stroke compared to those who worked 35-40 hours per week (Kivimäki et al., 2015). Furthermore, overworked employees commonly experience sleep disturbances, compounding the health risks by increasing the likelihood of stroke. The impacts on mental health are equally concerning, with heightened chances of depression, anxiety, and even suicide among those who consistently work long hours (Kivimäki et al., 2015).

Walker and Walker (1988) discussed how Manitoba farmers' stress can be due to difficulties balancing work and family life. Farmers considered time to be an important factor for a good quality of life, not only for leisure, spending time with family, or relaxation but also for thinking and planning (Contzen & Häberli, 2021). Farmers may find it challenging to take a break from work, making it tough to achieve a healthy work-life balance (Walker & Walker, 1988). They may have to work on weekends, causing stress in their personal lives and families (Finnigan, 2019). The proximity of their home to their farm can also be an additional source of stress (Contzen & Häberli, 2021) because there is no such thing as "what happens at work, stays at work". Furthermore, dairy farmers also risk occupational injuries because they tend to work alone for long hours (Karttunen & Rautiainen, 2013). When an individual works alone for extended periods, the risk of injury significantly increases (CCOHS, 2020). This is because no one is available to help in case of an emergency or accident. Working alone for long hours can lead to fatigue and exhaustion, impairing judgment and increasing the likelihood of accidents (Lerman et al., 2012).

The demanding nature of farm work and the need to be constantly present can lead to stress, isolation, and burnout (Chengane et al., 2021; Maslach, 2001). As a result, managing a farm requires considerable effort and sacrifices in terms of the time spent with animals or at the barn, which can exacerbate poor well-being and risk of injuries.

1.3.2 Farming with family and social support

1.3.2.1 Family and personal support

Farming alongside family members is a distinctive endeavor that blends the complexities of business with the dynamics of family relationships. The environment of a dairy farm sets it apart from other businesses, particularly in the context of Canadian dairy operations, which are predominantly owned and run by families. This creates a profound link between the family unit and the farm itself. The farm, the family, and the home collectively form an intricate system that presents daily opportunities and obstacles. Collaboration within the family setting allows for the establishment of a unified family vision encompassing both economic and social objectives, fostering a spirit of teamwork aimed at enhancing profitability. However, the pursuit of economic goals can face impediments stemming from unresolved issues among different generations, influenced by varying ages, life experiences, beliefs, and needs. Consequently, negative family dynamics can give rise to disagreements concerning the farm's objectives and the approaches for realizing them. Such discord has the potential to impact the farm's financial stability and profitability (Braun, 2019). Moreover, these unresolved issues are often exacerbated by stress, further intensifying the likelihood of discord. Additionally, farm life offers no respite from family matters, as the farm extends into the family's home due to the involvement of family members. Recognizing and acknowledging these stressors can help family members be more understanding and forgiving of occasional lapses when maintaining positive family dynamics. Despite these challenges, the key to the long-term sustainability of both the family and the farm lies in consistently striving to build and maintain strong family relationships (Jabbari et al., 2020).

In general, social relationships can act as a protective measure against mental health issues caused by the working environment (Kawachi & Berkman, 2001). However, finding time for personal relationships, leisure activities, and self-care can be challenging, leading to an imbalance that further affects mental well-being. Family members can play a crucial role in supporting someone's mental well-being. They can offer emotional support, provide a listening ear, and help in seeking professional help (Morgan et al., 2017). Additionally, family members can encourage healthy habits and help with daily tasks during challenging times. However, maintaining family

relationships comes with its share of pressure and stress (Thomas et al., 2017). If cohesion with family is difficult, mixing work and family can make things more complicated. It then becomes crucial for family members to have a clear understanding of each other's roles and decision-making processes. Inadequate communication can result in even more stress for the farmer, making it more challenging to overcome external factors such as adverse weather conditions.

1.3.2.2 Professional support and public perception

Developing solid professional connections in the farming industry may also play a crucial role in uplifting mental well-being (Finnigan, 2019; Wilton, 2019). For example, forming strong bonds with a trusted feed representative or veterinarian who can provide guidance on feeding practices and animal health can substantially ease the challenges experienced by farmers. Professionals working in agriculture, such as veterinarians, feed representatives and equipment suppliers, have a vital role in the farming community (Ritter et al., 2019). They regularly visit farms and engage with farmers and their families, offering expertise and support in various areas. Veterinarians visit farms to tend to both planned and emergency animal health issues, ensuring the welfare of the livestock. Feed representatives collaborate closely with farmers to assist in feed ration choices and productivity. While equipment suppliers provide a variety of machinery products to alleviate farmers' workload. In their respective roles, these professionals interact with farmers, provide decision-making support, and deliver valuable information and aid. They gain insights into farmers' lives during prosperous times and periods of stress and financial difficulties. These supportive networks can foster a sense of community and overall wellness in the farming sector. The investment of their time and effort into creating this relationship is important. Nevertheless, there has been limited scientific research into the specific role that agricultural professionals can play in identifying, alleviating, and supporting farming families during challenging times (Ritter et al., 2019). However, these professionals' time also costs money and this can be a great source of stress or reluctance to rely on these supports. More research needs to be done to study the impact of mental stressors on farming households and specifically explore how agricultural professionals contribute to supporting farmers' well-being during difficult times.

In terms of public perception, the influence of feeling supported or appreciated on mental health outcomes, is significant, playing a crucial role in helping individuals manage their emotions and enhance their overall sense of well-being (Harandi et al., 2017; Hansen & Østerås, 2019). Dairy

farmers work tirelessly to raise livestock, all intending to make a living and ensure that people have access to nutritious food. Being recognized and valued by the public not only acknowledges their hard work but also validates the importance of their role in society. This appreciation can give meaning and purpose to their dedication and labour (Finnigan, 2019). Alternatively, not feeling appreciated or even being threatened or targeted by animal activists can be a great source of poor well-being (Finnigan, 2019).

1.4 Farmer identity and planning for the future

Some dairy farmers are struggling with significant challenges related to their diminishing sense of identity within the community as producers (Burton, 2004). As generation-old traditions and ways of life disappear, farmers may find it increasingly challenging to uphold their purpose and connection to their farming heritage. This shift stems from factors like the introduction of automation, the growing pressure to embrace industrialized and mechanized farming methods (Stock & Forney, 2014), the pressure of farming, and fewer cow-farmer interactions. Dairy farmers regularly interact with their cows and closely observe their behaviour. While technology can help milk, feed, and bed cows and monitor their health and behaviour, it also diminishes the direct interaction between cows and farmers. While milking cows can be mundane, repetitive, and painful, it can also be very enjoyable and fulfilling for farmers. Further, the bond between the farmer and their animals enables the farmer to detect signs of discomfort or illness through the cow's body language and movements. This familiarity allows farmers to recognize indicators of unease or poor health based on the cows' behavioural patterns. Consequently, some farmers are facing difficulties in preserving their identity, their ties to local communities, and the enduring values that have shaped their livelihoods for centuries, ultimately posing potential risks to their well-being.

1.4.1 Farming and Job Satisfaction

Job satisfaction has been linked to lower levels of depression, anxiety, and burnout (Fisher, 2010). Farmers find more contentment and perform better when they feel familiar and comfortable with their farm system (Easterlin, 2003; Fisher, 2010). Furthermore, Graham (2005) discusses the 'Economics of Happiness' as an approach to evaluating human welfare, and he highlights that

focusing solely on income may overlook other important aspects. According to the 'Economics of Happiness,' people may prioritize non-financial factors when making choices. Previous research has often overlooked the importance of workplace happiness and its impact on performance (Easterlin, 2003; Fisher, 2010). Fisher (2010) suggests that job satisfaction leads to increased profit, superior performance, and positive effects on personal factors such as marriage and lifestyle.

1.4.2 Planning for the future

The Canadian dairy industry is integral to the country's agricultural sector, accounting for 9% of the total agricultural labour force, with 32,200 employees (Statistics Canada, 2023). The industry is mainly concentrated in Ontario and Quebec, and its growth potential is limited by the saturation of the domestic market, which may result in reduced labour demand over the next ten years (Statistics Canada, 2023). However, farmers are currently struggling to find and retain reliable employees in rural areas, which is becoming a growing concern (Finnigan, 2019). Moreover, some dairy farmers worry that they will not be able to transfer their business to their children or grandchildren because of the significant capitalization of total agricultural assets (Finnigan, 2019). This issue plays a significant role in the challenges related to the intergenerational transfer of farm properties, particularly the high cost of land, the need for significant investment in modern farming equipment, and the increasing complexity of farm management (Finnigan, 2019).

1.4.2.1 Evolution of the dairy industry and succession planning

In 2017, there were 1,200 unfilled dairy farming jobs in Canada, primarily in the areas of milking, herd management, and farm maintenance, which is equivalent to 3.8% of the total number of workers needed (Statistics Canada, 2023). Labour shortages cause excessive stress and delayed expansion, while lost sales are less common but still result in losses of \$148 million for the industry (Statistics Canada, 2023). According to the most recent census report, the agricultural sector in Canada is undergoing a process of consolidation and aging. The average age of farm operators in 2021 rose one year to 56, with the median age increasing from 56 to 58. Over 60% of farm operators were aged 55 or older in 2021, representing an increase from 54.5% in 2016. However, there is a positive development in the industry - the number of women farmers increased by 2.3%, from 77,970 in 2016 to 79,795 in 2021 (Statistics Canada, 2023). This development is seen as a positive indication for the industry, as it brings in new perspectives and approaches, diversifies the

industry's leadership, and helps address the gender imbalance in the sector. The census data further indicates a 1.9% decrease in the number of farms from 2016 to 2021. However, the decline in the number of farms was the smallest in 25 years (Statistics Canada, 2023).

The percentage of farms with a succession plan increased from 8.4% to 12% from 2016 to 2021 (Statistics Canada, 2022). This increase is significant as it ensures the continuity of farm operations, helps prevent the loss of agricultural land, and supports the industry's long-term sustainability (Finnigan, 2019). Additionally, a study by Hansen et al. (2020) found that having a successor is associated with improved farmer well-being. Statistics Canada suggests that the aging trend and COVID-19-related challenges may have contributed to an increase in the proportion of farms reporting having a succession plan. Furthermore, Firman et al. (2023) echoed these observations, revealing that many farmers relied on informal plans and only initiated succession planning when a family member showed interest in pursuing a career in dairy farming. These revelations point to a potential lack of proactive and strategic planning within the agricultural community.

Regarding employment, the number of hired workers from off-farm increased by 3.8%, with full-time off-farm workers accounting for 66% (Statistics Canada, 2022), indicating a move towards a more diversified workforce (family members and employees). In contrast, young operators (under 35 years) decreased from 9.1% in 2016 to 8.6% in 2021 (Statistics Canada, 2023). There are significant obstacles for young individuals looking to enter the agricultural industry, particularly for those who do not come from multi-generational farming backgrounds. Acquiring the necessary resources such as quota, land, equipment, and capital to operate a farm is a financial challenge (Kontogeorgos et al., 2017), especially considering that younger people generally have less wealth than older individuals (Finnigan, 2019). Even for those born into family farms, there may be limited opportunities to take over the family business due to consolidation in the agricultural sector (Finnigan, 2019). Furthermore, some individuals who can inherit family farms may opt not to do so, citing the considerable challenges of rural life compared to urban or suburban living.

Given these findings, it becomes evident that delving deeper into the connections between financial stability, business transitions, and mental health outcomes among dairy farmers is crucial. The agriculture industry is burdened by significant stressors. It is essential to not only understand why fewer young people are drawn to careers in agriculture, but also to consider the needs of aging

farmers. Without a younger generation poised to take over farming responsibilities, aging farmers are left grappling with demanding physical and mental labour, alongside the typical challenges associated with aging.

1.4.2.2 Planning changes

Several factors need to be considered when implementing modern practices and technology in the farming industry, particularly those that involve artificial intelligence (AI). One of the major concerns is the financial cost associated with such systems. These technologies require significant investment to develop, install and maintain, which can be a barrier for many farmers struggling to make ends meet (Hansen et al., 2020). While AI-powered systems can streamline processes and increase efficiency, they can also make certain tasks redundant, leading to farmers losing their identity. There is significant diversity among farmers and their farming systems. Some may be motivated to embrace new innovations while others prefer to stick to familiar practices (Vanclay, 2004). According to Hansson (2013), farmers prioritize reducing risk in their farm business to secure their family's lifestyle and future. One of the main goals for a farmer is to develop the farm as a place where their children will want to work in the future (Vanclay, 2004). However, it was found that farmers' plans for their farm business depend on their stage of life. Farmers in the early stages of their career aim to increase profit and production and are willing to take risks to achieve these targets (McDonald, 2013). Factors such as farmers' age and the importance of succession influence their decision making in terms of increasing production on the farm (McDonald, 2013). Young farmers have higher expectations for their farm and envision themselves working on the farm in the future, which encourages them to increase investment in the farm. McDonald (2013) found that young farmers were 11 times more likely to adopt new technologies compared to older farmers. The farmer's stage of life also determines the amount of risk they are willing to take in an investment, which depends on the amount of disposable income required for the family (Läpple et al., 2015; Vanclay, 2004). A young farmer with a young family has the flexibility to invest to ensure there is disposable income available for the family in the future. An older farmer with a mature family may have fewer family members depending on their farm income and may be content to continue with practices they are comfortable with without looking to change or increase production (Vanclay, 2004). In a study carried out by Läpple et al. (2015), young farmers were more inclined to partake in profit-making activities such as increasing production because they

realize the need to generate profit for financial security and to maintain a preferred lifestyle. According to Tse et al. (2018), farmers who adopted robotic milking system did so because of perceived improvements to their quality of life as well as their cows.

1.5 Housing, bedding, and farmer well-being

In the latter part of the 20th century, the development of improved techniques for harvesting and preserving grass, forage, corn, and alfalfa in the form of silage, together with increased availability of high-quality supplements and increasing demand for milk products, gave farmers the incentive to keep cows indoors for more extended periods (Medeiros et al., 2022; Phillips et al., 2013). Much work has been focused on enhancing milk production, quality, and animal health through adequate housing conditions. Nonetheless, it is crucial also to contemplate the effect of these housing systems on the well-being of farmers. (Cook et al., 2016).

1.5.1 Housing system and management

The dairy industry has been slowly shifting from traditional tie stalls to modern loose housing systems. As awareness of animal welfare concerns grows, the industry aims to improve dairy cattle health while maintaining productivity and income for farmers (Burkholder, 2000; Roche et al., 2009; 2015). The type of housing system significantly impacts animal health, welfare, disease resistance, and the spread of microbiological contamination (Witkowska & Poniewaź, 2022). Farmers play a crucial role in ensuring optimal livestock health by choosing housing systems that maximize herd productivity while reducing labour and expenses (Van Aken et al., 2022). In Canada, tie stalls are common, particularly in Quebec and Ontario, while loose housing systems, specifically free-stall barns, are more prevalent in Western Canada (Von Keyserlingk et al., 2009). Loose housing systems and tie stalls both have strengths and weaknesses in terms of dairy cow performance, health, fertility, and behaviour. Loose-housed cows generally have more behavioural freedom, social interactions, lower disease prevalence, and increased herd productivity (Beaver et al., 2021; Witkowska & Poniewaź, 2022). However, some suggest that loose housing systems make it challenging to assess animal behaviour or detect disease early, leading to prolonged treatment periods or premature culling (Beaver et al., 2021). Further, the free-stall system with automated manure removal is the least conducive to hoof health, with a higher disease prevalence

and shorter herd life (Witkowska & Poniewaź, 2022). The available literature does not provide clear evidence that supports a preference for one housing system over another regarding health (Von Keyserlingk et al., 2009). However, several welfare issues have been associated with tie stalls, which restrict the animal's movement and can cause stereotypic behaviours (Witkowska & Poniewaź, 2022). Although tie stalls can benefit dairy cattle if managed appropriately (Von Keyserlingk et al., 2009). Indeed, tie stalls can provide comfortable and clean stalls, optimize airflow, keep feed, and water accessible, and enable efficient manure removal (Popescu et al., 2013). Additionally, cows on concrete floors have a greater risk of lameness than those on rubber floors (Oehm et al., 2020). Rubber matting can help reduce animal health costs (Faye and Lescourret, 1989; Hultgren, 2002). Wet, slippery, and rough floors may increase stress on a cow's hoof, potentially leading to lameness, especially in free stalls (Kujala et al., 2010). Regarding mastitis, tie stalls can have a higher prevalence because of bedding contamination (Praks et al., 2007). However, group housing such as in free stalls and bedded pack may lead to drawbacks including higher chances of spreading diseases, competition, and aggression over essential resources (Costa et al., 2016).

The housing system chosen by dairy farmers can affect veterinary and maintenance costs, impacting farm profitability and the farmer's well-being. Veterinary expenses significantly impact overall profitability, so they must be considered when making farm management decisions (Odermatt et al., 2018). Recent studies suggest that loose housing for livestock can reduce veterinary costs and the need for antibiotics in Switzerland (Van Aken et al., 2022). Swiss researchers also found lower veterinary costs in free stall farms (Odermatt et al., 2018). Antibiotics are used less frequently in free stalls, which can lower farmers' costs. Mastitis is a multifaceted problem, and determining its financial impact can be difficult. An investigation in Canada showed that the average expense of one clinical mastitis case on Canadian farms amounted to 744 CAD (~537 USD) (Aghamohammadi et al., 2017). Heikkilä et al. (2012) found that the cost of mastitis could increase by 28% due to premature culling. On the other hand, the incidence of lameness resulting from foot disorders is more widespread in free stalls, with an estimated average cost of 95 USD compared to 18 USD per case for foot disorders that do not cause lameness (Bruijnis et al., 2010). It is important to note that Odermatt et al. (2018) recognized that using veterinary expenses to assess farm profitability has its limitations. Low costs may be due to having healthy animals or a lack of disease detection and sufficient veterinary care.

When choosing a cow housing system, it is important to consider the associated human labour inputs and unit operating costs for manure removal and storage. Different housing systems are more efficient depending on the herd size. Free-stall systems are better for managing large herds (Hansen, 2000). They improve milk quality, increase yields, and reduce energy and labour needs. For herds with over 100 animals, free-stall barns need up to 30% less labour than tie-stall barns. However, farms with more than 70 cows may have reduced labour needs for feeding and cleaning in free-stall barns as compared to tie stalls (Hansen, 2000). However, this advantage is often counterbalanced by an increase in milking labour inputs. In other words, while the free-stall barn system reduces the labour required for feeding and cleaning, more labour is needed for milking cows (Hansen, 2000). Additionally, using an automated scraper or manure robot can reduce human labour inputs (Rodenburg, 2012; Wardal, 2015). Although tie stalls may require more labour per cow for feeding and milking, they can allow dairy farmers to observe health issues in individual cows and their feed intake more closely (Hansen, 2000).

1.5.2 Bedding management

When choosing bedding materials for dairy cows, farmers need to take several factors into account, such as the cost, availability, ease of handling, and the potential for pathogen growth. In the dairy industry, various materials, including straw, wood chips, sand, and compost, are utilized to meet the diverse needs and preferences of farmers (Schütz et al., 2019). While mattresses can provide comfort for the cows, they can also increase the risk of lameness and swelling of hocks. On the other hand, mattresses can also keep cows cleaner, reducing the amount of time farmers need to spend on cleaning therefore reducing their workload (Van Gastelen et al., 2011); however, swollen and injured hock scores tend to be higher when compared to other bedding materials. Straw is soft and composts well but can increase the risk of mastitis. Sand, on the other hand, is economical, promotes cow cleanliness, and reduces lameness (Van Gastelen et al., 2011) but can be tough on equipment and, if not reclaimed, very expensive (Lopes et al., 2021). Straw and hay are often used for bedding because they are soft, provide thermal insulation, and are good for composting. They can also help reduce the farmer's bedding cost. Sawdust, however, contains more bacteria compared to other bedding types (Dyck et al. 2009; Hogan et al. 1989; Zdanowicz et al. 2004).

Researchers have shown that bedding costs and availability of bedding materials are major concerns that dairy producers express (Endres, 2009). Bedded packs and other deep bedding systems provide excellent cow comfort but require frequent tilling and strict hygiene of cows. These barns also reduce manure storage costs, required space, and handling expenses (Lorimor et al., 2006). However, bedded packs use four times as much bedding as free stall barns (Gilker, 2012) making them the most expensive bedding material at 425 USD per cow annually (Smith et al., 2017). In contrast, free stalls had the lowest cost of bedding material at 108 USD per cow per year and 236 USD for tie stalls (Smith et al., 2017). Endres (2012) also reported similar findings and concluded that the cost of bedding for dairy farmers using bedded packs was significantly higher than for farmers using free stalls. Barberg et al. (2007) also reported a similar result, stating that the cost of bedding for packs was the greatest concern. Despite the added cost, bedded packs were found to reduce the occurrence of lameness and increase cow comfort (Lobeck et al., 2011). Although few studies have focused on comparing various bedding materials in terms of costs, Harrison et al. (2008) reported that woody bedding tended to be more expensive than other bedding materials. Panivivat et al. (2004) mentioned that long wheat straw and sand were the most expensive bedding materials for dairy calves in Arkansas, followed by granite fines, wood shavings, and rice hulls.

Economies of scale can significantly impact the cost of bedding for dairy farms. The cost of bedding per cow per year decreases as herd size increases. This means larger farms benefit from lower production costs due to economies of scale. Economies of scale lead to lower production costs including bedding on larger dairy farms (Laughton et al., 2014; McBride and Greene, 2009; MacDonald et al., 2007). Furthermore, Tauer and Mishra (2006) found that the higher production costs of smaller dairies were primarily due to inefficiencies in resources utilization. This suggests that larger farms are more cost-effective when it comes to bedding and more efficient overall.

Based on current observations, few trends are apparent due to the large variability between and within housing and bedding types. Like any system, optimum management is necessary to achieve desirable results. There are many options for dairy cattle, and producers should choose the option that will work best for their well-being as well as their animals, but there is limited information that relates specifically to the well-being of producers.

1.5.3 Effect of housing and bedding on farmer well-being

Most research on housing and bedding for animals has focused on how it affects their health and behaviour, but it has overlooked how these systems can impact the mental well-being of farmers. The cost of bedding material varies between different systems (Endres, 2009; Smith et al., 2017). This cost difference could affect farmers' mental health if some farmers have higher expenses than others. However, this relationship is not straightforward due to several factors to consider. Factors such as savings in veterinary costs and labour requirements should be considered. Added to this the farm size and the efforts made by farmers to ensure their cows' comfort also play a role in this. Reducing farmers' workload could reduce the risk of injuries. In addition to physical health risks, overworking has also been associated with significant mental health issues such as depression and anxiety (WHO, 2022).

1.6 Feeding system and farmer well-being

Dairy farming is an expensive enterprise, with feed expenses accounting for half of the total operating costs (Vandehaar, 1998). Therefore, improving feed efficiency is crucial for dairy farmers, especially given the high feed cost. Proper nutrition is vital for high milk production and can be more profitable than reducing feed costs (Vandehaar, 2011). As farms continue to grow, traditional feed-handling tools may become inadequate. Upgrading the feed handling system can help dairy farmers meet the demands of a larger herd (Ali et al., 2020). There is an anticipated increase in feed storage and handling needs due to the projected rise in livestock production and animal feed consumption (Makkar, 2018). Moreover, the trend towards free stall housing is expected to continue, as livestock operations tend to adopt this management style when their herds expand (Hansen, 2000).

Livestock farming increasingly turns to automation to handle repetitive tasks and high workloads. This has led to the development of automatic feeding systems, which offer farmers the potential to reduce their daily workload, improve production quality, and minimize feed wastage (Romano et al., 2023). Although feed costs have slightly eased up in Eastern Canada in 2023, decreasing by 8.6% since January, they remain high (Farm Credit Canada, 2023). In August 2023, they were almost 44% higher than in January 2020, when Statistics Canada started monitoring the data.

Therefore, effective feed management is key to prevent feed wastage and to keep costs under control. Two primary ways of feeding dairy cows exist component feeding and total mixed ration (TMR) feeding. Component feeding involves providing cows individually with specific forages, protein supplements, and grains, with the feed amount measured by weight or volume (Ferland et al., 2018). TMR feeding is the most common method for indoor-housed dairy cows, particularly high-producing cows. This method ensures a balanced diet with the amount of energy required by each cow (Santa et al., 2022). A lot of what is documented about the nutrition of dairy cows is focused on the individual cow. This includes consideration of the cow's size, body condition, milk fat and protein content, an individual cow's capacity to consume concentrate, and, of course, milk production itself (Erickson & Kalscheur, 2020). The TMR system does not account for any of these factors on an individual cow basis, and some may argue against TMR on this basis. The TMR system, by its nature, is designed to address cows on a group basis rather than an individual cow basis (Maltz, 2020). Feed can be delivered manually which implies mixing and delivering feed in a tractor whereas automated feeding involves using an automated feed mixing or delivery system such as robot, conveyer or a combination of both.

Using a TMR system can increase feed utilization and milk production, as well as reduce digestive and metabolic problems in cows, if done properly (Santa et al., 2022; Schingoeth, 2017). Automated feeding systems (AFS) can improve feeding precision, reduce operator workload, and benefit animal welfare (Romano et al., 2023). However, effective planning and consideration of site features is necessary to maximize the robots' flexibility, as AFS vary in operator support and installation complexity. Frequent feedings can positively impact cow health and milk yield but require precise timing, the right portions, and a comprehensive understanding of cows' dietary needs (DeVries, 2019). Automated feeding and innovative equipment can take over the daily feeding of animals (Ali et al., 2020).

In terms of farmer mental health, King et al. (2021) found that farmers who feed their cows manually experience higher levels of stress, anxiety, and depression compared to those who use automated feeding systems. They also revealed that farmers using automated feeders showed greater resilience. This suggests that automated feeding systems could potentially alleviate stress and improve the well-being of farmers by reducing the need for manual labour and allowing more

time for other farm tasks and family responsibilities. Therefore, AFS could reduce long working hours which have a negative impact on the well-being (Chang et al., 2020).

1.7 Milking system and farmer well-being

In recent years, the dairy industry has seen the introduction of fully automated or robotic milking systems that significantly reduce the need for human labour. However, these systems work optimally when cows are permanently housed and can be difficult to manage when they graze far from the barn or are housed in tie stalls (Witkowska & Poniewaź, 2022). The dairy industry has made significant strides in maximizing milk production, with automated milking systems (AMS) and automatic milking rotary (AMR) parlours representing the latest technological advancements. These systems offer the potential for frequent milking events without relying on human labour (de Koning et al., 2002). Robot milkers' popularity is growing rapidly throughout Canada, with more than 1 in 5 farms currently using this technology (Agriculture Census, 2021). One of the primary advantages of automation is its ability to replace manual labour for milking (Acemoglu & Restrepo, 2019). However, it does not necessarily save working hours; it simply changes the type of labour and the flexibility of that labour. The most enticing initial aspect of an AMS to a dairy farmer may be relief from the daily milking routine. This technology also has automatic sensors that monitor each cow's health and production, such as udder health, milk production, reproductive status, feed intake, and body weight changes (Jacobs & Siegford, 2012). This provides detailed information about each cow, which was previously difficult to obtain with traditional milking systems. By monitoring the health and production of individual animals more carefully, modern milking systems enable dairy farmers to detect small changes within each cow to predict illness more quickly and observe trends in the overall herd production (Jacobs & Siegford, 2012). AMS technology also has the advantage of controlling milking frequency on an individual cow basis to adjust for production levels without incurring additional labour costs (Jacobs & Siegford, 2012). However, an AMS also comes with potential disadvantages. The reliance on sensors to measure compromised health parameters may take the detection process out of the hands of the dairy farmer and delegate it to a machine (Neethirajan, 2023). With the automation of these measurements comes an influx of an enormous amount of data, which could be misinterpreted, misused, or overwhelming (Jacobs & Siegford, 2012). Farmers may become overwhelmed by the number of

variables they can monitor. As AMS are integrated into farms with larger herds, facility details such as the number of robots per pen and traffic type become increasingly important (Tremblay et al., 2016). While the number of robots must increase to accommodate approximately 50-60 cows per unit, farmers may need several robots if it helps to increase production efficiency as well as redundancy in case one AMS breaks down (Tremblay et al., 2016).

According to a recent study by King et al. (2021), dairy farmers who utilize AMS may have better mental health than Canadian farmers in general. In another Canadian study, Tse et al. (2018) found that dairy farmers using AMS reported that their work was now less stressful and physically demanding. This decrease in physical discomfort coupled with enhanced time flexibility could potentially empower farmers with the energy and capacity to allocate more attention to other farm tasks. In conclusion, modern milking technology has revolutionized the dairy industry by providing a more flexible and efficient way to manage cows. This advanced technology enables producers to remotely monitor and control the milking process, optimizing milk production and cow health. With the help of AMS, farmers can enjoy a more relaxed lifestyle as they do not have to be present during the milking process (Tse et al., 2018), which can take up a significant portion of their day. AMS can identify changes in cow behaviour and milk quality, notifying farmers early about compromised health to prevent milk loss and improve herd health. Robotic milking has transformed dairy farming, offering a more effective and lucrative approach to farming.

1.8 Research methods to understand interconnections

The dairy industry is a complex system with several interconnections. Therefore, understanding the connection between farmer well-being and the management factors will require to collect several variables ranging from management decisions to personal life. Surveys can gather much quantitative information at once, making them versatile tools for research to study the bigger picture on the farm. When comparing surveys to qualitative research methods such as interviews, focus groups, and observations, surveys offer the advantage of providing more standardized and consistent data, which can be easily combined and analyzed. Variables of interest include demographic information, farm responsibilities, work-life balance, social environment and support, specific stressors related to dairy farming, succession planning, and housing and animal management. Mental health can be measured by using validated psychological questionnaires to

assess stress, anxiety, depression, and emotional resilience. These questionnaires have been previously used to evaluate the mental health of Canadian farmers from various commodity groups (King et al., 2021; Jones-Bitton et al., 2020).

1.8.1 System thinking approach

System thinking is a great tool to remind us always to consider the bigger picture. Van Mai (2010) believes that system thinking is a powerful tool for addressing complex problems and identifying leverage points for intervention because of its capability to describe the interrelationships among economic, social, and environmental subsystems. It can be simple to figure out how to disassemble items into simple comparisons, but it can be quite difficult to comprehend how the various components work together to form the whole system (Arnold & Wade, 2015; Duboz et al., 2018). In short, system thinking is about investigating what factors and interactions could contribute to a possible outcome in a system.

Suppose we apply system thinking to the dairy farm to help improve dairy farmer well-being. In that case, we need to know about animal health and welfare and the management factors that represent the environment, the people, and the social factors. By learning to view dairy farms as a series of components of a system and by understanding the different components within them, we can begin to better understand farmers' mental and physical well-being. Despite its potential, systems analysis within animal science remains limited (Stephens, 2021). There exists a set of tools that can be successfully used to describe parts of the system and how they function, as well as what interconnections exist between system components and how they impact system behaviour (Stephens, 2021).

System dynamics, one of the most widely used and validated approaches in decision-making, applies system thinking in modelling that describes the relationships among variables (Tedeschi et al., 2011). A few studies have explored the system thinking approach to answer complex questions in animal science. For example, the challenges faced by the beef value chain in Iran, were explained by Alizadeh et al. (2020) who used a system thinking approach. They highlighted the use of system thinking to identify problems in the livestock value chain. Due to the unstructured nature of these problems, multiple factors, and the dynamic environment, a big picture of the system was necessary for planners and policymakers to make informed decisions. Moreover, Habanabakize et al. (2022) used a system thinking approach to create a typology of livestock that

accurately reflects the realities of Senegalese farmers as they face the ramifications of global climate change and its accompanying societal responses. However, the lack of understanding of the problems unique to each farmer's production system and the presumption of homogeneity have resulted in inefficient resource utilization and inappropriate intervention planning in the Senegalese dairy industry (Habanabakize et al., 2022). The typology confirmed a dynamic relationship between several variables, such as varying production goals and quantities, market access, animal breeds, and livestock management systems. Therefore, a comprehensive understanding of each farming system is required to enable decision-makers and relevant stakeholders to identify specific interventions required by farmers based on their individualized needs.

1.8.2 Using systems thinking to understand farm management and farmer well-being

Limited investigations exist on what affects the mental well-being of dairy farmers, which reduces the opportunities to address the challenge. Researchers have predominantly relied on statistical methods such as univariate and multivariate analysis to conduct their studies. While univariate analysis examines variables separately, multivariate analysis explores relationships among two or more variables simultaneously. These methods have been used to investigate a wide range of topics related to dairy farming, from milk production and herd management to the economic viability of different farming practices. The insights gained through these analyses have helped researchers to understand the complexities of dairy farming better and to identify areas for improvement. However, it is advisable to adopt a systems approach to understand how farm management impacts the well-being of dairy farmers. This approach considers all the elements of the farm management system, including the social, economic, and environmental factors that affect the farmers. By examining these factors holistically, we can obtain a more accurate picture of the complex relationship between farm management and dairy farmer well-being, which can inform policies and practices that support the well-being of dairy farmers. To gain a system view of the dairy farm and the stressors associated, the Multiple Factor Analysis (MFA; Pagès, 2004) becomes useful. It is an example of a multivariate data analysis method for summarizing and visualizing a complex data set in which individuals are described by several sets of quantitative variables. In this comprehensive analysis, multiple sets of variables are considered at the same time.

1.9 Thesis Objectives

The objectives of this research are to benchmark farmer well-being across Western Canada and Ontario and to use systems thinking to better understand interconnections between farm management and farmer well-being. More specifically, I will:

- i) Estimate the prevalence of mental and physical health outcomes among dairy farmers in Western Canada and Ontario (Chapter 2).
- ii) Compare mental and physical health outcomes between different housing types, barn design, automation, and other management factors (Chapter 2).
- iii) Holistically explore the relationships between dairy farmer well-being and farm management (Chapter 3).

CHAPTER 2 | How it feels to be a dairy farmer: Farm management and well-being of dairy farmers in Western Canada and Ontario.

Abstract

Dairy farming is known to be one of the most physically and psychologically demanding professions worldwide. Dairy farmers confront numerous challenges that can significantly affect their well-being, such as long working hours, physical exertion, financial pressures, and unpredictable weather events. This study aimed to explore how the farm environment, housing type, milking system, and other farm-level factors relate to the mental and physical well-being of farmers. Dairy farmers (n=115) from Western Canada and Ontario, completed a questionnaire covering demographics, farming responsibilities, work-life balance, social environment and support, animal housing and management, specific stressors, physical health, and validated psychometric scales to assess stress, anxiety, depression, and resilience. T-tests, ANOVA, and chi-squared tests were used to compare means with general population averages and tested associations between mental health scores, physical health outcomes, and survey variables. The study found that dairy farmers experience higher levels of stress ($P<0.001$), anxiety ($P<0.001$), and depression ($P=0.04$), and have lower resilience ($P<0.001$) compared to the general population, with women scoring more severely on anxiety and depression scales. Concerns were also raised about the physical health of dairy farmers, as most reported work-related injuries, and health issues, with major injuries including bruises (54%), chronic joint pain (44%), lacerations (34%), and fractures (32%). In this study, the occurrence of injuries seemed to be related with the age of farmers, as older farmers sustain more injuries. A significant difference was found when comparing the cause of the injury and gender ($P = 0.01$); men tended to report more machinery and work environment injuries than women. However, health outcomes did not differ based on animal housing and management, farm responsibilities, and financial and transition planning variables ($P>0.1$). Significant differences were observed when comparing mental and physical health to work-life balance, social environment and support, and specific dairy stressors. The main sources of concern were farm finance, feed cost, weather, and workload constraints. This study highlighted the positive impact of maintaining a good work-life balance and strong social relationships on farmers' mental

health. While dairy farmers seem to have similar well-being in different production systems, farmers most concerned about dairy farming-specific stressors had poorer well-being in general.

2.1 Introduction

Farming is widely recognized as one of the most physically and psychologically demanding professions globally (Hassard & Tech, 2013; Hounsome et al., 2012). Dairy farmers face numerous challenges that can significantly impact their well-being, including long working hours, physical exertion, financial pressures, and unpredictable circumstances (Finnigan, 2010; Fraser et al., 2005; Jones-Bitton et al., 2019). There are growing concerns about the potential link between the intensification of dairy farming and its impact on farmer well-being (Cook et al., 2016). This is reflected in the higher rates of poor mental health and suicide among farmers compared to similar socio-economic groups (Gregoire, 2002; Hagen et al., 2021; Jones-Bitton et al., 2020; Rudolphi et al., 2020; Torske et al., 2016). Therefore, understanding the well-being of farmers is crucial, particularly considering the substantial annual contribution of \$15.5 billion from dairy production to the Canadian economy (Government of Canada, 2022).

There is a lack of comprehensive data regarding the overall health and well-being of Canadian dairy farmers and the main stressors they face. These lacking data hinder efforts to address the unique challenges of this group. Canadian dairy farms display a diverse range of housing types, barn designs, milking systems, and management practices, reflecting the industry's variety. This study aims to describe the well-being of dairy farmers, including the complexities of social interactions and the important role of family support. It also explores how the daily responsibilities of caring for animals on a dairy farm can affect the farmers' well-being, while also examining the specific challenges, stressors, and potential support systems related to animal management within the context of dairy farming.

2.2 Materials and Methods

2.2.1 Study Design

A cross-sectional, observational study was conducted from May 2023 to April 2024. Dairy farmers were asked to complete an online questionnaire using Qualtrics (Provo, UT, USA). Farmers were recruited across British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario. The inclusion criteria required participants to be over 18 years old and be a primary or secondary/co-decision-maker in a commercial dairy farm in one of the targeted provinces. Participants were compensated with a choice to receive a 15CAD Tim Hortons gift card as an honorarium for their time. The study protocol was approved by the Research Ethics Board at the University of Manitoba (HE2022-1459) and informed consent was obtained from all participants before they began the questionnaire and throughout the process. To recruit participants, provincial dairy boards, feed companies, and veterinarians were asked to share our study information with farmers. Farmers were also contacted through phone numbers and emails found on public-facing farm websites. Additionally, farmers were also recruited at farm events and tours. Our study was advertised on social media (Twitter, LinkedIn, Facebook) and shared by other organizations and individuals.

2.2.2.1 Surveying Farmer Well-Being

The survey (see Appendix 3) used validated psychological questionnaires to assess stress, anxiety, depression, and resilience and questions on occupational injuries and farm management. These questionnaires have been previously used to evaluate the mental health of Canadian farmers from various commodity groups such as dairy, beef and pig farmers (Jones-Bitton et al., 2020; King et al., 2021; Thompson et al., 2022).

To assess stress, we used the Perceived Stress Scale (PSS) which is a 10-item self-report questionnaire that assesses an individual's perception of the general stress in their life and how well they can handle it (Cohen et al., 1983). The PSS is widely recognized as one of the most effective methods for measuring stress and can be used to identify individuals at risk of specific psychiatric disorders (Cohen et al., 1983). This scale has been used with Canadian farmers in the past (Hagen et al., 2021; Jones-Bitton et al. 2020; King et al. 2021). The questions in this scale ask about feelings or thoughts, participants have to indicate how often they felt a certain way using a

5-point Likert scale ranging from 0 (never) to very often (4) in the past month. Higher scores indicate higher stress. A score of 0 to 13 is considered low stress, 14 to 26 is considered moderate stress, and 27 to 40 is considered high stress (Cohen et al., 1983).

The Generalized Anxiety Disorder-7 (GAD-7) was used to screen for and assess the severity of anxiety symptoms severity. This scale has established validity and reliability; however, it cannot be used as a diagnostic tool, it is a tool to perform initial screening for generalized anxiety disorder (Splitzer et al., 2006). Similar to PHQ-9, participants were asked to rate how often they have been bothered by specific problems over the past two weeks. Items are rated on a four-point Likert scale ranging from 0 (not at all) to 3 (nearly every day). The GAD-7 scores range from 0 to 21, categorizing anxiety symptoms as none or minimal (0-4), mild (5-9), moderate (10-14), or severe (15-21). A score of 10 or higher represents a reasonable cut point score for identifying cases of generalized anxiety disorder (Splitzer et al., 2006).

The Patient Health Questionnaire-9 (PHQ-9) was used to screen and assess the severity of symptoms of depression. This scale has been shown to be valid and reliable, with the PHQ-9 recommended for use in primary care to assess depression severity and treatment efficacy (Kroenke et al., 2001). Additionally, PHQ-9 has been found to have good internal consistency and test-retest reliability, making it useful for identifying potential cases of depression (Kroenke et al., 2001). Participants were asked to rate how often they have been bothered by specific items over the past two weeks on a scale from 0 (not at all) to 3 (nearly every day). The PHQ-9 score ranges from 0 to 27, categorizing depressive symptoms as none (0-4), mild (5-9), moderate (10-14), moderately severe (15-19), or severe (20-27). A score of 10 or higher represents a reasonable cut-point score for identifying cases of major depressive disorder (Kroenke et al., 2002; Spitzer et al., 1999).

The Connor Davidson Resilience Scale (CD-RISC) 10-item version was used to assess the participants' resilience, which means their persistence and hardiness in the face of adversity (Connor & Davidson, 2003). Respondents had to rate their level of agreement with ten statements about resilience in the past month. This scale also uses a 5-point Likert scale ranging from 0 (not true all the time) to 4 (true nearly all the time). Total scores range from a minimum of 0 to a maximum of 40 with higher scores indicating greater resilience.

Physical and occupational health was assessed by asking participants to provide details about the injuries they sustained while working on their farm. They were asked to select the type of injuries or health problems they sustained with options including ‘Broken bones’, ‘Bruise/Contusion’, ‘Respiratory diseases’, and ‘Chronic joint pain’ (Appendix 3). They were also asked, ‘What caused the injury?’ with response options including ‘Machinery or equipment,’ ‘Work environment,’ and ‘Animal-related.’ They were also asked to report on the quality and satisfaction of their sleep (Appendix 3).

2.2.2.2 Surveying Farm Management and Life on the Farm

Our survey was developed and reviewed by several researchers, farmers, and staff at provincial milk boards to ensure its relevance to both the dairy industry and our research objectives. Our survey was divided into six main sections: demographics, farming responsibilities, work-life balance, social environment and support, animal housing and management, and specific stressors (Appendix 3). Participants were asked a series of questions related to their farm management, including the duration of their farm management, their regular tasks, and the amount of time spent working alone. Additionally, they were asked about their ability to maintain a work-life balance, take vacation, and find time for rest, recreation, and things that bring them joy. Other inquiries pertained to the size of their operation, their housing type, and management practices. Farmers were also asked about their future operation plans, succession planning, and financial records. We used a Likert scale, ranging from 1 (never) to 5 (very often), to determine the level of stress experienced by farmers in relation to various stressors. These stressors included financial concerns (i.e., farm finance, milk prices, quota value, etc.), weather-related issues (i.e., wildfires, flooding, drought, etc.), and industry-related challenges (i.e., concerns about animal activists, public perception, new technology, etc.).

2.2.3 Sample Size

There are approximately 4,500 dairy farms in Western Canada and Ontario (Government of Canada, 2023). Using a post-hoc sample size calculation with an allowable error of 5%, a

confidence level of 95%, and the prevalence of high stress (9%), anxiety (2.6%), and depression (2.6%) in our sample, the minimum required sample size ranged from 39 to 123 (Dean et al., 2013; www.OpenEpi.com)

2.2.4 Statistical Analyses

The survey results were analyzed using means, standard deviation (SD), ranges, and proportions or prevalence for mental health outcomes; indicating the proportion of a given population exhibiting specific characteristics within a specific time period. The mental health and physical health outcomes were also examined in relation to key demographic factors such as age, province, and gender. Responses that were not completed (less than 2% missing) were included in calculating averages but were not used to compare specific variables. Participants with two or more missing responses on a mental health scale were excluded from the analysis for that scale (Thompson et al., 2022). Instructions on how to calculate and categorize the total scores for the outcome variables (PSS, GAD-7, PHQ-9, and CD-RISC) were provided in each scale's manual. All statistical analyses were performed using R, and statistical significance was set at $P < 0.05$, with tendencies declared at $P < 0.1$. Scores from GAD-7 and PHQ-9 were non-normally distributed, and transformations were applied to normalize them. T-tests and ANOVA were used to compare means with general population averages and to test associations between mental health scores and survey variables. Chi-squared tests were used to compare physical health variables.

2.3 Results and Discussion

2.3.1 Study population

A total of 115 farmers participated in this study. The majority of survey responses (83%) were collected between April 2023 and October 2023, with some late responses received between February 2024 and April 2024. This study is part of a One Welfare project where the authors also visited a subset of 66 farms to collect animal health data for a separate study. Therefore, the authors decided to gather the survey responses after visiting those farms. For this reason, most survey responses for Western Canada were collected during the spring and summer of 2023 (May to July

2023), while most responses from Ontario farmers were obtained in the fall (September to October 2023). The age group with the highest representation was 35 to 44 years, making up 37% of the participants (n=43), followed by 25 to 34 years, which comprised 27% of the total (n=31) (Table 2.1). Most farmers had been managing their farms for 10 years or more (55%, n=63), followed by 5 to 9 years (28%, n=32) (Table 2.1). In terms of gender, most participants (70%, n=80) identified as men (Table 2.1). All provinces under study were represented, with Ontario having the highest representation (49%). More details about the characteristics of the sample population can be found in Table 2.1.

2.3.2 Prevalence of Mental Health Outcomes

Mean scale scores of demographic factors are presented in Table 2.1 and comparisons to each scale's normative population data in Table 2.2.

2.3.2.1 Stress

The average PSS score of our farmers was 17.3 ± 6.8 , which is significantly higher than the normative population mean (13.0 ± 6.34 ; $P < 0.001$; Table 2.2) (Cohen et al., 1988). The mean PSS score for women (18.5 ± 6.98 ; Table 2.1) was not significantly different than that for men (16.8 ± 6.6 ; $P = 0.2$). Of the surveyed participants, 24% were considered low stress, 67% were considered to show moderate stress, and 9% were high stress (Figure 2.1) There was no statistically significant difference in the perceived stress score based on age groups ($P = 0.3$) and the time spent managing the farm ($P = 0.5$). There was a significant difference when comparing provinces ($P = 0.02$). Farmers in British Columbia reported the highest average Perceived Stress Scale (PSS) score of $21.4 (\pm 6.9)$. In contrast, Alberta and Manitoba had the lowest PSS scores, with $15.2 (\pm 6.6)$ and $14.8 (\pm 7.4)$, respectively (Table 2.1). When comparing perceived stress scores between the provinces, there was a significant difference between BC and Alberta (21.4 ± 6.9 vs 15.2 ± 6.6 ; $P = 0.03$) and BC and Manitoba (21.4 ± 6.9 vs 14.8 ± 7.4 ; $P = 0.03$). There was no difference comparing Saskatchewan with other provinces. There was also no difference when comparing the stress scores of primary and secondary decision-makers ($P = 0.2$).

2.3.2.2 Anxiety

The average anxiety score was 4.91 (± 4.26), and it was statistically higher than the GAD-7 normative population mean (2.97 ± 3.35 ; $P < 0.001$; Table 2.2) (Löwe et al., 2008). The percentage of individuals with a positive screening for Generalized Anxiety Disorder (GAD), indicated by a score higher than 10 on the GAD-7, was slightly higher among our farmers (16%; Figure 2.2) compared to the Mental Health Research Canada (MHRC) reported scores for Canadians in spring 2023 (15.0%) and summer 2023 (14.0%). Among study participants, 13% reported scores indicating moderate anxiety disorder symptoms, which was higher than the Canadian average (10%; MHRC, 2023). However, our participants had a lower percentage of symptoms indicative of severe anxiety disorder (3%) compared to the 2023 Canadian average (5%). Additionally, a lower proportion of farmers showed minimal anxiety symptoms (52% vs. 62%), and a larger proportion of farmers showed mild anxiety disorder symptoms (32% vs. 24%). Further analysis revealed that women had statistically higher anxiety scores (6.3 ± 5.48 ; Table 2.1) than men (4.3 ± 3.4 ; $P = 0.04$). Regarding provinces, significant differences were found when comparing the anxiety scores between BC and Alberta (8.8 ± 4.2 vs. 3.3 ± 3.0 ; $P < 0.001$), BC and Manitoba (8.8 ± 4.2 vs. 3.61 ± 4.87 ; $P = 0.002$), and BC and Ontario (8.8 ± 4.2 vs. 5.1 ± 4.0 ; $P = 0.02$). There was no significance difference comparing Saskatchewan to other provinces. Farmers who had managed the farm for 10 or more years reported a lower anxiety score (4.3 ± 3.8) than those who managed it for 1 to 4 years (7.4 ± 5.6 ; $P = 0.05$). There was no significant difference when comparing primary and secondary decision makers ($P = 0.9$) and age groups ($P = 0.2$) (Table 2.1).

2.3.2.3 Depression

The average PHQ-9 score was 5.21 (± 4.35) and was statistically higher than the general population norm (2.91 ± 3.52 ; $P = 0.04$; Table 2.2) (Kocalevent et al., 2013; Table 2.2). The prevalence of a positive depressive disorder (i.e., PHQ-9 score >10 ; Figure 2.3) was lower in our farmers (16%) compared to all Canadians in 2023 (23%; MHRC, 2023). When compared to the Canadian average in spring 2023, a smaller portion of farmers exhibited symptoms indicative of minimal depression disorder (49.6% vs. 54%) and more farmers (34.8% vs. 23%) were classified as having mild symptoms. The reported proportion of moderate symptoms was consistent between our

participants and Canadians (13%; Figure 2.3). However, more Canadians had moderately severe to severe depression symptoms compared to our farmers (12% vs. 2.6%). There tended to be a significant difference between the average scores for women (6.4 ± 5.1) and men (4.69 ± 3.46) ($P = 0.08$) (Table 2.1). There tended to be a provincial difference in depression scores as well ($P = 0.09$). Moreover, there was no statistically significant difference between the age groups ($P = 0.2$), the time spent managing the farm ($P = 0.2$; Table 2.1) and when comparing the primary and secondary decision makers ($P = 0.6$).

2.3.2.4 Resilience

In our study, we found that the average CD-RISC score was 28.1 (± 6.0) and it is significantly lower from the average score of the general population (31.8 ± 5.4 , $P < 0.001$; Table 2.2) (Campbell-Sills et al., 2009). Additionally, around 70% of participants in our study scored lower than the general population average. Primary decision makers were more resilient than secondary decision makers (29.6 ± 5.2 vs 26.4 ± 6.4 ; $P = 0.004$). When comparing different age groups, there appeared to be a difference in resilience scores ($P = 0.06$; Table 2.1) with farmers aged 65 or older showing higher resilience. There was no significant difference between the resilience scores of women (27.6 ± 6.7) and men (28.3 ± 5.7 ; $P = 0.6$) as well as when comparing provinces ($P = 0.5$).

This study revealed that the mental health scores of dairy farmers were notably higher in stress, anxiety, depression, and lower in resilience compared to the general population. These results are consistent with findings of Jones-Bitton et al. (2020), where scores for stress, anxiety, and depression were higher, and resilience lower, than reported normative data. Interestingly, Canadians tended to score in the most severe categories, but more farmers scored in the mild and moderate categories of anxiety (GAD-7) and depression (PHQ-9). A similar observation was made by Thompson et al. (2022) who compared farmers' mental health scores to Canadians during COVID-19. They found that more Canadians scored in the most severe categories, but more farmers scored in the moderate categories of anxiety and depression. Survey-based studies may underestimate levels of mental health issues in farming as farmers can be hard to reach and individuals with poor mental health may be less likely to respond or participate in this type of study (King et al., 2021; Torvik et al., 2012). Although there was no clear association between age and mental health disorders, it is worth noting that younger farmers tended to report numerically

higher average stress, anxiety and depression (Table 2.1). The lack of a significant difference might be due to individuals within each age group facing more pronounced mental health challenges compared to others. The findings also indicated that, quantitatively from a limited sample of 115 people, there was no significant evidence supporting the presence of a gender difference in stress and resilience among dairy farmers. However, women scored more severely on measures of anxiety and depression which is consistent with previous studies (Jones-Bitton et al., 2020; Thompson et al., 2022). This finding has been observed as one of the most widely documented findings in psychiatric epidemiology where women are significantly more likely than men to develop an anxiety disorder throughout their lifespan (Bruce et al., 2005; Regier et al., 1990). Furthermore, the data brought to light the concerning mental health outcomes of farmers in British Columbia, specifically with respect to anxiety and stress. However, the lack of comprehensive mental health research across different provinces makes it challenging to compare these findings with existing regional studies. It is important to consider that these disparities may be influenced by various factors, such as the timing of the study and persistent underlying issues like climate change and inflation. Moreover, the findings revealed that dairy farmers with 10 or more years of experience in managing their farms tended to experience lower levels of anxiety compared to those with 1 to 4 years of experience, indicating that experience in dairy farming might offer some protection, leading to a reduction in the severity of anxiety symptoms among farmers. Regarding decision-making status, this research indicated that primary decision-makers exhibited higher levels of resilience compared to secondary decision-makers, suggesting that primary decision-makers may be better equipped to handle and recover from challenges and setbacks. Alternatively, secondary decision-makers may experience more stress if they have less control over the farm, including a limited ability to make choices and implement changes, especially if the farm's primary decision maker's choices do not align with their own values, which may cause frustration.

2.3.2.5 Physical Health

Among the participants we surveyed, 82% have experienced work-related injuries or health problems. Our farmers mention sustaining work-related injuries due to a combination of factors. Farmers identified "machinery, working environment, and animals" as the predominant cause of their injuries (22%, Figure 2.4), followed by "working environment and animals" (17%), and "working environment" (14%). The most common types of injuries reported include major bruises

(53.9%, n=62; Figure 2.5), chronic joint pain (44.7%, n=51), lacerations (33.9%, n=39), and broken bone fractures (32.2%, n=37). The occurrence of injuries seems to be correlated with the age of farmers. Unsurprisingly, all farmers aged 65 years or older reported sustaining serious work-related injuries (Table 2.3). Additionally, 88% of individuals in the 35-44 age group and 77% of those in the 25-34 age group have also experienced serious work-related injuries (Table 2.3). Regarding sleep, more than half of the farmers reported sleeping 5 to 6 hours per night (53%, n=61), and 6% reported sleeping less than 5 hours per night. When compared to Canadian adults, less farmers met sleep duration recommendations of 7 hours per night (41% vs. 66%; Wang et al., 2022). Moreover, when asked about the quality of their sleep, 56% reported not getting enough sleep. In our study, we found that there were no significant differences in mental health scores based on the number of hours of sleep per night ($P > 0.1$; Table 2.12) However, farmers who believed they were getting enough sleep had lower stress levels than those who did not (14.8 ± 6.9 vs. 19.4 ± 6.0 ; $P < 0.001$). Additionally, those reporting getting enough sleep also had lower levels of anxiety (3.76 ± 3.14 vs. 5.86 ± 4.80 ; $P = 0.02$) and depression (3.46 ± 2.82 vs. 6.61 ± 4.86 ; $P < 0.001$). We also found that there was no significant difference when comparing the hours of sleep, getting enough sleep, and the cause of the injury to factors such as age group, province, farm management time, and primary or secondary decision-making roles ($P > 0.1$). However, a significant difference was found when comparing the cause of the injury and gender ($P = 0.01$); men tended to report more machinery and work environment injuries than women.

Our research raises important concerns regarding the physical health of dairy farmers. A majority of the dairy producers we surveyed reported sustaining work injuries or health problems while working on their farms. This indicates that dairy farming carries various risks, which can stem from every area of the farm. Working with heavy animals is just one perilous aspect of dairy farming. Farmers are also at risk of injury from heavy machinery, manure storage systems, and more. The working environment can significantly impact farmers' safety. Moreover, distractions and poor maintenance of the barn can create numerous hazards, potentially leading to accidents. Farming is associated with many hazards for people of all ages, and unfortunately, farmers often become so accustomed to their daily routines that they overlook some of these hazards. In this study, the occurrence of injuries seems to be related with the age of farmers, as older farmers sustain more injuries. This trend suggests that injuries and health issues may become more prevalent within the farming population as they age. Research has shown that farmers with arthritis,

rheumatism, hearing impairments, or visual acuity loss are at a higher risk of agricultural injuries (McCurdy and Carroll, 2000; Lewis et al., 1998). Moreover, older farmers often use older machinery that may lack safety features (Hansen, 1986). Additionally, decreased reflex speed in older farmers may make them more vulnerable to injuries (Etherton et al., 1991). However, this difference may be because these farmers have been in the industry longer than younger farmers, so they may have experienced more injuries or health problems.

According to Watson et al. (2015), adults should strive to obtain a minimum of 7 hours of sleep each night to uphold optimal health. More than half of our participants do not meet the minimum sleep requirement per night. Consistently sleeping for fewer than 7 hours per night can result in detrimental health consequences, including weight gain, obesity, diabetes, hypertension, heart disease, stroke, depression, and an elevated risk of mortality (WHO, 2022). Additionally, more than the half reported not getting enough sleep, while the quality and duration of sleep significantly affect mental health, playing a vital role in regulating emotions, cognitive function, and overall psychological well-being (Scott et al., 2021; Vandekerckhoven et al., 2018). Poor sleep is also especially dangerous for farmers, who often operate heavy machinery and handle large livestock (Shortall et al., 2018), and can lead to farm-related injuries (Heaton et al., 2010; Spengler et al., 2004). In this study, men tended to report more machinery and work environment injuries. It is well recognized that men engage in more behaviour that exposes them to the risk of injury, experience more injuries, and die more frequently from injuries (Udry, 1998). According to several studies, the risk of farm-related injury is greater for men than for women (Hagel et al., 2004; McCurdy & Carroll, 2000). Our results were also consistent with Dimich-Ward et al. (2004) who found that a greater number of men farmers were injured, regardless of how the occurrence of injury was categorized, particularly when farm machinery was involved.

2.3.3 Surveying Farm Management and Life on the Farm

2.3.3.1 Farm responsibilities and work-life balance

In this study, it was observed that most participants work every day (77%, n=88; Table 2.6), while a small percentage work six days a week (23%). All farmers reported juggling multiple tasks daily.

Among the surveyed farmers, 39% selected being responsible daily for tasks such as animal care, cleaning the barn, managing finances, milking cows, and seasonal cropping. Only 12% reported being responsible for 3 tasks or less (Table 2.6). Almost 47% of the farmers (n=54) spent over 60% of their time working with animals, and the same percentage worked alone most of the time. A minority of farmers (5%) reported being able to take time to rest or do activities that bring them joy every day, while 50% could only manage to do so a few times per week. It was also noted that 10% of farmers did not take any vacation time at all, and 28% took less than 6 days annually. Only 31% of farmers reported being able to achieve a healthy work-life balance, while the majority were sometimes able to do so (53%). In this survey, we did not provide a specific definition of work-life balance because we recognize that farmers have a unique lifestyle, and their responsibilities fluctuate. As a result, the meaning of work-life balance varies for each individual. We specifically left this up to each participant to interpret work-life balance according to their own experiences in order to capture the diverse realities of farmers' lives.

Further analysis found that there were no significant differences in mental health scores when comparing factors such as time spent with animals, time working alone, daily tasks, number of days worked per week, and vacation time ($P > 0.1$). However, noticeable differences were observed when comparing perceived stress and resilience scores in relation to achieving a healthy work-life balance ($P < 0.001$; Table 2.6). Farmers who were able to maintain a healthy work-life balance had lower perceived stress scores (13.7 ± 6.4) compared to those who were only sometimes able to (18.1 ± 6.0 , $P = 0.007$) and those who could not achieve this balance (21.0 ± 7.1 , $P < 0.001$). In addition, they showed higher resilience scores (30.4 ± 7.0) compared to those who did not achieve this balance (25.4 ± 5.8 ; $P = 0.01$).

Scores for anxiety, stress, and depression did not significantly differ based on the amount of time allocated to rest or do activities that brought them joy per week, except for resilience. Farmers who had time for rest/recreation almost every day had higher resilience scores (31.6 ± 6.6) compared to farmers who had time for rest/recreation a few times during the week (27.4 ± 5.2 ; $P = 0.03$) or less than once per week (25.1 ± 6.7 ; $P = 0.01$). In terms of physical health, the number of hours farmers slept at night was significant when it came to having time for rest/recreation ($P = 0.04$). Furthermore, it was observed that a higher proportion of farmers reported getting enough sleep and were also able to maintain a healthy work-life balance ($P < 0.001$; Table 2.7).

The findings suggest that the dairy sector has a culture of working long hours, which has had a significant impact on the physical and mental well-being of farmers. The majority of farmers in this study work every day, consistent with Statistics Canada's report that most operators (80%) work over 40 hours per week on average. Working long hours has been linked to health issues such as sleep deprivation, which can further impact well-being (Hale, 2005; Virtanen et al., 2009). Hale (2005) found that those who work more than 50 hours per week have an increased risk of sleeping less than 6.5 hours per day compared to people who work less than 35 hours per week. According to Kivimäki et al. (2015), there is a strong correlation between extended working hours and an increased risk of heart attacks and strokes, especially among individuals in lower socio-economic status groups. The effects on mental health are equally worrying, with a higher likelihood of depression and anxiety among those who consistently work long hours (Kivimäki et al., 2015). While this study did not provide clear evidence of a significant association between working days and mental health scores, it is important to note that maintaining a healthy work-life balance by allocating equal hours to work and personal life is crucial. It was observed that farmers who achieved a healthy work-life balance and rested more often during the week experienced lower stress and greater resilience. Therefore, the number of days worked per week plays a vital role in enabling individuals to achieve this balance and have time to rest. Unfortunately, many of our farmers face significant challenges in achieving a healthy work-life balance. The reality is that many farmers cannot afford not to overwork because dairy farming can be demanding. Many feel compelled to embrace exhaustion as a sign of dedication, but the personal and social costs should not be overlooked (Wilkie, 2010). This demanding workload, compounded by the need to be constantly present, can lead to stress, isolation, and burnout (Chengane et al., 2021; Maslach, 2001). This aligns with the expectations placed on farmers to ensure optimal production. This responsibility can result in high levels of psychological stress (Kato et al., 2022). Which poses risks to their safety and well-being and can lead to increased risk of injuries, stress, loneliness, and decreased motivation (Rook et al., 1987). Farmers may find it challenging to take a break from the farm or finding reliable employees to cover for them, making it difficult to achieve a healthy work-life balance (Walker & Walker, 1988). In terms of physical health, the study found that most farmers who reported getting enough sleep were also able to maintain a healthy work-life balance. Although our research does not establish causation, it does show an association between being able to balance work and personal life and getting enough sleep. Having sufficient time for oneself,

one's family, and one's personal activities may enable farmers to have a well-organized day, allowing them to get enough sleep.

2.3.3.2 Social environment and support

Social relationships can act as a protective measure against mental health issues caused by the working environment (Kawachi & Berkman, 2001). However, finding time for personal relationships, leisure activities, and self-care can be challenging, leading to an imbalance that further affects mental well-being. The survey data reveal that the average number of workers was $6.64 (\pm 12.1)$. Most farmers reported working with both family members and employees (62%, $n = 71$; Table 2.8), followed by solely family members (34%, $n = 39$) and only employees (4%, $n = 4$). It was noted that farmers who worked with only family members reported lower anxiety (3.94 ± 2.59 vs. 9.75 ± 7.5 ; $P = 0.04$; Table 2.8) and depression scores (4.28 ± 3.42 vs. 11.5 ± 9.3 ; $P = 0.007$) when compared to those working with only employees. Similarly, those who worked with both family members and employees (5.34 ± 4.24) also exhibited lower depression scores compared to those who worked solely with employees ($P = 0.02$). Most participants (83.3%, $n = 95$) answered affirmatively when asked if they felt they had someone to talk to at work. When looking at satisfaction levels within their social circle, more farmers (30.4%, $n = 35$) expressed being 'very satisfied' with the support they receive at home instead of the support received at work (19.1%, $n = 22$). Alternatively, a comparable percentage of farmers felt 'very dissatisfied' with the support they received at home and work (6.1%, $n = 7$). Another interesting finding was that having someone to talk to at work was associated with lower anxiety scores. Farmers who had someone to talk to at work reported lower anxiety compared to those who did not (4.40 ± 4.00 vs 7.00 ± 4.52 ; $P = 0.03$). Additionally, the level of support received at home had a significant impact on farmers' mental health. Those who felt 'satisfied' with the support at home experienced less stress, anxiety, and depression compared to those who felt 'dissatisfied' or 'neutral' about the support at home ($P < 0.05$) (Table 2.8). Furthermore, the study found that farmers who were 'very satisfied' with the professional support at work exhibited higher levels of resilience than those who were 'neutral' about the support (30.4 ± 5.17 vs. 26.3 ± 6.4 ; $P = 0.04$). These results highlight the importance of family in dairy farming and the ability for farmers to feel more understood or are more likely to talk to or be vulnerable with family members. Farmers who report working with

family members tended to have better mental health than farmers working with employees. Working with family members has both advantages and challenges. Trust can be stronger, but making tough decisions affecting family can be difficult. Family can share common values and create a strong sense of unity. It can help carry on a family legacy and offer crucial support for mental health. However, maintaining boundaries and professionalism in a family business can be challenging. On the other hand, hiring employees brings diverse perspectives, professional growth, meritocracy, and networking opportunities. The challenges will include the lack of trust and the lack of flexibility in terms of work hours. These results also shed light on the importance of social support both at home and in the workplace in contributing to the mental well-being and resilience of farmers. When looking at physical health, the number of hours of sleep was associated with who the farmers work with ($P = 0.004$), if they have someone to talk to ($P < 0.001$) and if they have support at home ($P = 0.002$), meaning that higher proportion of farmers who work with family members and employees, as well as farmers who only work with family members, get more sleep (Table 2.9). Perhaps managing employees is not only a source of anxiety or depression, but it may also take up more time which otherwise could be devoted to sleep. And finally more farmers who reported having someone to talk to were able to get 5 to 6 hours of sleep per night on average (Table 2.9).

In terms of professional relationships, a higher percentage of farmers (52%, $n=60$; Table 2.9) reported being "highly satisfied" with the support received from their veterinarian, and 50% ($n=57$) reported being "highly satisfied" with their feed representative. Additionally, 30% ($n=34$) were "satisfied" with their veterinarian, and 40% ($n=46$) were "satisfied" with their feed representative. Only 3% ($n=3$) and 2% ($n=2$) of the farmers were "neutral" about the support from their veterinarian and feed representative respectively. Furthermore, only 0.87% expressed dissatisfaction with their veterinarian, while none of the farmers reported dissatisfaction with their feed representative. This may reflect the ability of farmers to switch nutritionists if needed, whereas it is much more difficult to find a new veterinarian in many parts of the country (COPS; 2022). These results underscore the importance of social connections and robust support systems within the farming community, which can significantly enhance mental health. Farmers must carefully consider feeding methods and cow health to maintain high milk quality. Having a reliable feed representative and veterinarian can significantly ease their burden. This study revealed that there were no significant differences observed in mental health scores based on the number of workers,

support from various professional entities such as veterinarians, feed representatives, and equipment suppliers, and whether farmers felt valued by the dairy industry.

In terms of public perception, nearly a quarter of the farmers reported feeling 'highly valued' by the dairy industry and consumers (22%, $n = 25$; 19%, $n = 22$, respectively; Table 2.8) in contrast to not feeling valued by the dairy industry (15%, $n = 17$) and consumers (10%, $n = 12$). Based on our study, farmers who felt highly valued by consumers reported lower levels of stress compared to those who did not feel at all valued (13.2 ± 6.0 vs. 22.6 ± 6.1 ; $P < 0.001$). Additionally, farmers who felt highly valued also exhibited lower levels of anxiety (2.18 ± 2.02) compared to those who felt not at all valued (8.92 ± 3.85 ; $P < 0.001$) or slightly valued (6.31 ± 3.81 ; $P = 0.002$). In terms of depression, farmers who felt highly valued reported lower levels of depression compared to those who felt not at all valued (3.84 ± 4.29 ; $P = 0.02$) and slightly valued (6.36 ± 3.73 ; $P = 0.04$). Regarding resilience, farmers who felt slightly valued (25.6 ± 5.76) exhibited lower resilience than those who felt very valued (30.5 ± 5.95 ; $P = 0.03$) and extremely valued (37.5 ± 3.5 ; $P = 0.05$). There is little documentation available of the relationship between dairy farmers and the dairy industry, which makes it challenging to evaluate and compare both relationships. However, it is not surprising that more farmers feel less supported by consumers, as this disparity between the public's perception of farming and its reality have been reported numerous times by farmers (Finnigan, 2019). The influence of feeling supported or appreciated on mental health outcomes is significant, playing a role in helping individuals manage their emotions and enhance their overall sense of well-being (Harandi et al., 2017). Being recognized and appreciated by the public and the industry they work in not only acknowledges their hard work but also validates the importance of their role in society. This appreciation gives meaning and purpose to their dedication and labour (Finnigan, 2019).

2.3.3.3 Housing and Animal Management

The average number of cows in this study was 150 ± 160 , ranging from 30 to 1100 cows. Currently, the average herd size in Canada is 100 cows, up from 77 cows per farm 10 years ago (Statistics Canada, 2022). The average number of cows in this study was 150 ± 160 , which was similar to Western Canadian average (152 ± 22 ; $P = 0.3$) reported by the Dairy Farmers of Canada (DFC),

but statistically different from the average in Quebec and Ontario (85 ± 10 , $P < 0.001$). There was no significant effect of farm size on mental health scores ($P > 0.1$).

The predominant housing method for cows adopted by our farmers were free stalls (79%, $n = 91$; Table 2.10), followed by tie-stalls (14%, $n = 16$) and bedded packs (7%, $n = 8$). Furthermore, 45% of participants' barns were of original construction ($n = 52$) and 25% were retrofit. In contrast, 30% of farms had undergone recent construction within the last five years ($n = 34$). Among the surveyed farmers, 59% utilize conventional pipelines for milking their cows ($n = 68$), while 41% employ automatic milking systems ($n = 47$). Most farmers possess concrete as their stall base (66%, $n = 76$) and 34% employ deep-bedded systems ($n = 39$). There was no significant difference between the well-being variables (mental and physical) and the number of cows, the milking system, the state of the barn, the stall base, the secondary base, and bedding ($P > 0.05$; Table 2.11). It was found that technology is being used in various aspects of farming. The survey revealed that 77% of the farmers use activity monitors ($n = 89$). In contrast, only 13% of the farmers individuals ($n = 15$), reported using automated feeding systems. Additionally, 58% of the farmers ($n = 67$) use automated manure scrapers, while 45% ($n = 52$) use milk quality monitors, and 53% ($n = 61$) use rumination monitors. Furthermore, the study also examined the relationship between the farmers' mental health scores and their use of technology. The results indicated that there was no significant difference between the mental health scores and the use of technology.

The assessment of the effects of animal management practices on the psychological well-being of dairy farmers constitutes a significant area requiring further investigation and comprehension. Larger dairy operations can lead to increased revenue, more employees, adoption of technology to reduce labor, and additional farm responsibilities. This, in turn, can result in more expenses and a possible work-life imbalance. Skilled farm labour is often in short supply and dairies may hire immigrant workers to address this labour shortfall. However, reliance on immigrant labour and any associated language barriers can lead to communication challenges resulting in errors in animal management including impaired disease detection and treatment (Barkema et al., 2015). These errors may lead to impaired animal care, and more veterinary costs. Difficulties associated with farm labour emerged as another prominent theme, particularly with regards to wages as agricultural work is often underpaid (Mendly-Zambo, 2023). As one farmer mention in Mendly-Zambo's report (2023): "It's nearly impossible to make a living as a farmer without exploiting

workers or the land.” The expansion of the farm brings about increased challenges for the farmer, making it more challenging to find and retain labour. As the farm grows, the workload also expands, creating additional demands on the farmer and the available labour force. However, no association was found between mental health scores and farm size (number of cows) in the current study. One of the possible reasons is that farmers who have smaller or larger farms have been accustomed to managing them for several years. As a result, they are in some way accustomed to this workload continually, and it no longer constitutes a stress factor. Another reason is that the relationship between farmer well-being and the number of cows is not linear, meaning that it would be better understood in a context where several variables are considered at the same time such as the number of workers, veterinary costs, and animal management.

Research has demonstrated that implementing proper management practices and integrating new technologies can lead to increased milk production, reduced labour, precise monitoring of individual animal health and productivity, and improved welfare for dairy cows (Jacobs & Siegford, 2012; Tse et al., 2018; Ventura et al., 2021). While a study by King et al. (2021) suggested that farmers using automated milking systems may have better mental health, our study did not find this association. Moreover, a Canadian study by Tse et al. (2018) found that dairy farmers utilizing automated milking systems perceived their work to be less stressful and physically demanding, but our results did not support this conclusion. The lack of significance may be because farmers in different production systems have mastered their management practices, or because they are experiencing post-purchase rationalization and choice-supportive bias. Post-purchase rationalization is the tendency for someone to overlook any faults or defects in a product or service in order to justify their purchase (Chatzidakis et al., 2009). Choice-supportive bias, on the other hand, is when we tend to attribute positive features to the options we chose and negative features to the options we did not choose (Kafaei et al., 2021).

2.3.3.4 Specific stressors and supporting resources

The impact of stressors on the mental health of dairy farmers is a crucial concern requiring attention. Participants in the study indicated that their greatest sources of stress in dairy farming were related to workload (47%; Figure 2.6), feed prices (43%), farm finances (42%), and weather

(41%). Interestingly, our farmers identified flooding (85%), wildfires (74%), and learning and implement new technology (62%) as the least stress-inducing factors. However, there was a positive association between anxiety and depression scores and concerns about wildfires ($P < 0.001$, $P = 0.001$; respectively; Table 2.13) and flooding ($P = 0.02$, $P < 0.001$; respectively). There were no significant differences in mental health scores when comparing drought concerns, pasture condition, weather, and value of quota. However, there were significant differences when comparing anxiety and depression with animal health and welfare concerns; for example, farmers who were very often concerned about animal health had higher anxiety (8.71 ± 6.07 vs. 3.15 ± 3.54 ; $P = 0.02$) and depression scores (9.86 ± 7.77 vs. 3.65 ± 3.26 ; $P = 0.01$) compared to those who were never concerned. Looking at concerns about farm finances, it was found that stress, anxiety, and depression were significantly associated with concerns about farm finances. Farmers who frequently worried about their farm finances experienced higher levels of stress (21.5 ± 6.24 vs. 13.1 ± 7.2 ; $P < 0.001$), anxiety (8.25 ± 5.18 vs. 2.25 ± 3 ; $P < 0.001$), and depression (8.68 ± 4.81 vs. 3.06 ± 3.77 ; $P < 0.001$) compared to those who were not concerned about farm finances. When looking at workload concerns, farmers who were frequently worried experienced higher levels of stress (22.8 ± 5.4 vs. 11.3 ± 5.2 ; $P < 0.001$), anxiety (7.72 ± 4.74 vs. 1.40 ± 1.77 ; $P < 0.001$), and depression (8.12 ± 4.88 vs. 2.50 ± 2.63 ; $P = 0.004$) compared to those who were never worried. Additionally, they exhibited lower resilience (25.6 ± 5.9 vs. 32.1 ± 6.6 ; $P = 0.05$). Similar patterns were observed for other concerns such as energy pricing, feed availability, feed cost, human resource management, learning new technology, personal finances, policy and regulations, public perceptions, continuation of quota, raw milk prices, marketing milk prices, and animal rights activists (Table 2.13). Regarding physical health, the number of hours slept was significant with animal health and welfare concerns ($P = 0.01$), personal finances concerns ($P = 0.02$) and workload concerns ($P = 0.002$). A higher proportion of farmers who were ‘never’ or ‘almost never’ worried about animal health and welfare concerns were sleeping less than 5 hours (Table 2.14). A higher proportion of farmers who were ‘almost’ never worried about personal finances were sleeping 5 to 6 hours and 7 to 8 hours compared to sleeping less than 5 hours (Table 2.14).

These findings were consistent with previous studies, which also identified unpredictable weather and economic pressures as the main sources of stress for farmers (Finnigan, 2019; Jones-Bitton et al., 2020). A study by Walker and Walker (1988) revealed that both male and female farmers in Canada were most stressed about their finances. Additionally, the Canadian Association for Farm

Safety (2005) reported that poor production and farm finances were the top stressors in farming. Another study by Sturgeon and Morrissette (2010) found that financial strain and a lack of control over farming variables such as weather and farm culture were major stressors in farming. While climate change and extreme weather events like floods and wildfires have been recognized as significant sources of financial stress for the industry (Abbas et al., 2022; Rocha et al., 2022), our farmers did not identify these as stress-inducing factors. Witnesses in the Finnigan (2019) report mentioned that farmers have been accustomed to dealing with the uncertainties of weather for generations. Nevertheless, it remains an uncertainty that affects their mental health, with those most concerned experiencing poorer mental well-being. Despite the potential challenges associated with technology, many farmers do not feel overly stressed when it comes to learning and adopting new technological advances. The introduction of new technology brings a vast amount of data, which can be daunting at times (Jacobs & Siegford, 2012). However, farmers who embrace technology on their farms often handle this influx of information relatively effortlessly or are satisfied with the support provided by their equipment suppliers. An interesting observation was that farmers who were less concerned about the health and welfare of their animals tended to sleep the least. Sleeping less can be a cause of this lack of concern. In fact, farmers can feel compelled to work harder and longer to ensure the good health of their cows. Further analysis of the herd's health can provide a more conclusive answer regarding this association.

2.3.3.5 Financial and Transition Planning

The results from the survey brought to light that 31% of the surveyed participants reported having a documented business plan, indicating that a majority of businesses lacked this crucial strategic tool (Table 2.15). Similarly, we found that 36% of the participants had a written succession plan in place, highlighting a potential gap in long-term planning for the continuation of their businesses. This result represents more than the reported value by Statistics Canada (2022), where the percentage of farms with a succession plan increased from 8.4% to 12% from 2016 to 2021. In addition, 18% of respondents stated that they conducted annual risk assessments while also maintaining written management/contingency plans. Furthermore, the findings from Canadian studies echoed these observations, revealing that many farmers relied on informal plans and only initiated succession planning when a family member showed interest in pursuing a career in dairy farming (Finnigan, 2019). When comparing mental health scores and physical health, there were

no significance difference with financial and transition planning variables ($P > 0.1$). These revelations highlight a potential lack of proactive and strategic planning, or reluctance to do so, within the agricultural community. Given these findings, it becomes evident that delving deeper into the connections between financial stability, business transitions, and mental health outcomes among dairy farmers is crucial. Understanding these connections is crucial for tailoring support programs to effectively address the unique challenges dairy farmers face and to help foster a sustainable and resilient farming community.

2.4 Limitations

This study is exploratory and cross-sectional, and participation is voluntary. As a result, the absence of recruitment biases cannot be guaranteed, and participants might either overestimate or underestimate the information they provide. Also, it is possible that farmers with better mental health were more inclined to participate in our survey. Previous research has suggested that individuals with poor mental health are less likely to participate in surveys, potentially leading to an underestimation of the prevalence of mental illness (Torvik et al., 2020). Moreover, it is possible that more progressive farmers are more inclined to take part in this type of research, resulting in a sample consisting of 41% AMS, while the average proportion of farms using AMS in the studied provinces is 22% (Government of Canada, 2023). Additionally, most participants completed the survey during spring, summer, and fall, a time of high stress during harvest therefore, our estimates may have been overestimated or reflective of the worst time of year.

2.5 Conclusion

The study found that dairy farmers experience higher levels of stress, anxiety, and depression, and have lower resilience compared to the general population. It highlighted the positive influence of maintaining a good work-life balance and strong social relationships on farmers' mental health. The study also raised concerns about the physical health of dairy farmers, as the majority reported work-related injuries and health issues. Our research revealed the intricate connections within dairy farming and how farmer well-being can be associated with management practices. Farmers

face multiple stressors simultaneously, and a more comprehensive analysis is needed to comprehend these dynamics fully.

Appendix 1

Table 2.1 Demographic variables and mental health scores describing survey participants

Variable	Number of farmers	Proportion	Stress	Anxiety	Depression	Resilience
Gender			P=0.2	P=0.04	P=0.08	P=0.5
Women	35	30%	18.5 (±7.0)	6.31 (±5.48)	6.40 (±5.12)	27.6 (±6.7)
Men	80	70%	16.8 (±6.6)	4.30 (±3.46)	4.69 (±3.89)	28.3 (±5.7)
Age group			P=0.3	P=0.2	P=0.2	P=0.06
18 – 24 years	3	3%	14.7 (±2.1)	4.00 (±5.29)	3.67 (±2.52)	32.7 (±1.5)
25 – 34 years	31	27%	19.1 (±6.8)	5.84 (±5.16)	6.39 (±5.51)	27.5 (±6.4)
35 – 44 years	43	37%	17.8 (±6.9)	5.30 (±3.46)	5.42 (±3.85)	26.9 (±5.9)
45 – 54 years	17	15%	15.9 (±6.5)	5.00 (±5.28)	5.12 (±4.68)	27.4 (±6.1)
55 – 64 years	18	16%	15.3 (±6.8)	2.89 (±2.74)	3.33 (±2.79)	31.0 (±4.9)
65 or older	3	3%	14.7 (±2.1)	2.33 (±1.53)	3.33 (±1.53)	33.3 (±5.5)
Province			P=0.02	P<0.001	P=0.09	P=0.5
Ontario	52	45%	18.0 (±6.1)	5.12 (±4.02)	5.62 (±3.91)	27.7 (±5.9)
Manitoba	18	16%	14.8 (±7.4)	3.61 (±4.88)	4.94 (±5.70)	30.4 (±5.5)
Saskatchewan	4	3%	18.0 (±6.1)	3.75 (±3.50)	5.00 (±5.60)	27.2 (±4.8)
Alberta	26	23%	15.2 (±6.6)	3.35 (±3.02)	3.46 (±3.93)	27.8 (±6.5)
British Columbia	15	13%	21.4 (±6.9)	8.80 (±4.18)	7.20 (±3.76)	27.6 (±6.6)
Time managing the farm			P=0.6	P=0.04	P=0.2	P=0.5
10 or more years	63	55%	16.9 (±6.3)	4.30 (±3.82)	4.52 (±3.51)	28.1 (±6.0)
5 – 9 years	32	28%	18.0 (±6.6)	5.06 (±3.92)	5.75 (±4.57)	27.6 (±5.8)
1 – 4 years	17	15%	18.2 (±8.7)	7.41 (±5.61)	7.06 (±6.23)	27.8 (±6.0)
Less than 1 year	2	2%	10.5 (±4.9)	0	2.0 (±2.8)	35.5 (±2.1)
Decision making			P=0.2	P=0.9	P=0.7	P=0.004
Primary	60	52%	16.5 (±7.1)	4.90 (±4.44)	5.05 (±4.60)	29.6 (±5.2)
Secondary	55	48%	18.2 (±6.3)	4.93 (±4.08)	5.38 (±4.09)	26.4 (±6.4)

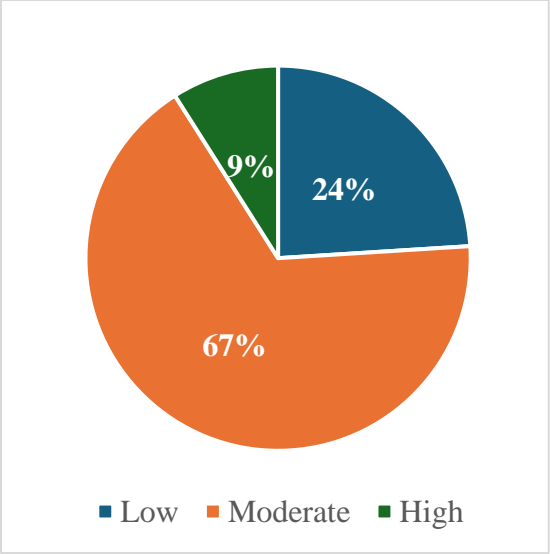


Figure 2.1 Classification of surveyed participants on PSS

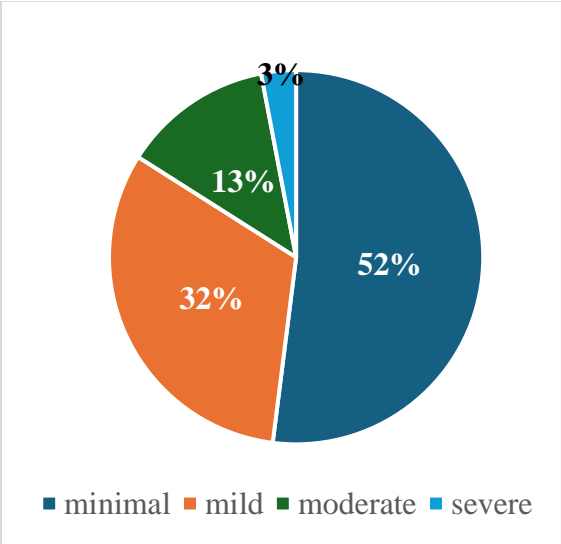


Figure 2. 2 Classification of surveyed participants on the GAD7

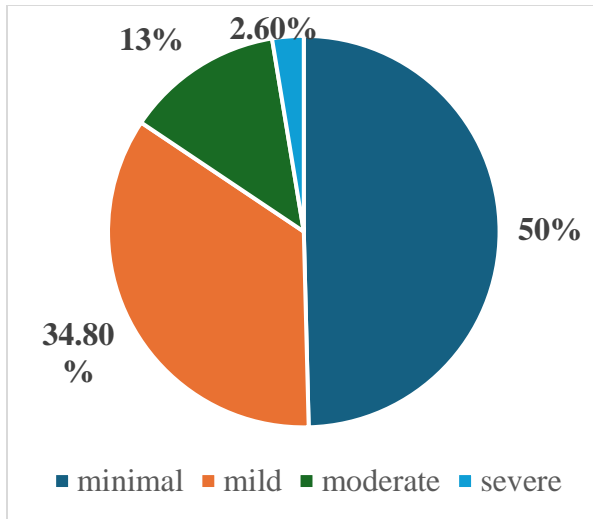


Figure 2.3 Classification of surveyed participants on the PHQ-9 scale

Table 2.2 Descriptive statistics for each numerical variable with comparisons to national averages

Variables	Survey mean (\pm SD)	Range	Norm mean (\pm SD)	P value
PSS	17.3 (\pm 6.8)	0-33	13.0 (\pm 6.3)	<0.001
GAD-7	4.91 (\pm 4.26)	0 – 21	2.97 (\pm 3.35)	< 0.001
PHQ-9	5.21 (\pm 4.35)	0 - 24	2.91 (\pm 3.52)	0.04
CD-RISC 10	28.1 (\pm 6.0)	10 – 40	31.8 (\pm 5.4)	<0.001
Number of cows	150 (\pm 6.8)	30 - 1100	152 (\pm 22) ^a 85 (\pm 10) ^b	0.3 <0.001

^a Western Canada average herd size

^b Ontario and Quebec average herd size

Table 2.3 Comparing demographic characteristics to physical health outcomes

Variable	Getting enough sleep		Sleeping hours			%Injured
	No	Yes	7-8 hours	5-6 hours	< 5 hours	
Gender	P = 0.06		P = 0.5			
Women	21%	9%	P = 0.3			78%
Men	35%	35%	7-8 hours	5-6 hours	< 5 hours	84%
Age	P = 0.9		P = 0.2			
18 – 24 years	1%	2%	3%	0%	0%	67%
25 – 34 years	16%	11%	10%	16%	0%	77%
35 – 44 years	21%	16%	16%	18%	3%	88%
45 – 54 years	8%	7%	7%	7%	1%	80%
55 – 64 years	9%	7%	4%	10%	2%	78%

65 or older	2%	1%	0%	0%	1%	100%
Province	P = 0.1		P = 0.6			
Ontario	29%	16%	20%	21%	4%	84%
Manitoba	6%	9%	6%	10%	0%	78%
Saskatchewan	3%	0%	1%	3%	0%	75%
Alberta	10%	12%	7%	14%	2%	81%
British Columbia	7%	6%	7%	6%	0%	86%
Time managing	P = 0.7		P = 0.9			
10 or more years	29%	25%	22%	30%	3%	82%
5 – 9 years	17%	10%	11%	15%	2%	81%
1 – 4 years	8%	7%	7%	7%	1%	87%
Less than 1 year	1%	1%	1%	1%	0%	50%
Decision making	P = 0.4		P = 0.07			
Primary	27%	25%	17%	30%	5%	86%
Secondary	29%	19%	23%	23%	1%	77%

Table 2.4 Comparing farm responsibilities variables to mental health scores

Variable	Freq	%	Stress	Anxiety	Depression	Resilience
Time alone			P = 0.2	P = 0.6	P = 0.6	P = 0.7
0-20%	7	6	17.7(±6.7)	4.86(±5.40)	6.00(±4.43)	29.4(±5.6)
21-40%	19	17	16.3(±5.6)	4.16(±3.95)	4.89(±4.72)	28.4(±5.0)
41-60%	35	30	16.7(±7.8)	4.94(±4.41)	4.74(±4.67)	28.4(±6.0)
61-80%	43	37	16.9(±5.8)	4.77(±4.05)	5.12(±3.85)	28.1(±6.2)
81-100%	11	10	22.0(±7.7)	6.73(±4.61)	7.09(±4.70)	25.6(±7.8)
Tasks			P = 0.2	P = 0.9	P = 0.4	P = 0.2
Animal care, cleaning, cropping and finances	8	7	17.9(±7.4)	6.4(±5.1)	7.1(±5.4)	31.1(±3.7)
Animal care, cleaning, cropping, finances and milking	45	39	17.4(±7.5)	5.0(±4.6)	5.2(±4.7)	28.4(±5.9)
Animal care, cleaning, cropping and milking	23	20	19.1(±5.5)	5.0(±3.6)	6.3(±4.5)	26.1(±5.8)
Animal care, cleaning, finances and milking	11	10	15.7(±6.2)	5.6(±5.6)	4.2(±4.7)	27.6(±8.3)
Animal care, cleaning and milking	14	12	14.3(±6.6)	3.7(±2.9)	3.7(±3.1)	29.0(±5.1)
Animal care, cropping, finances	10	9	16.2(±4.5)	4.00(±3.24)	4.30(±1.92)	30.1(±6.0)
Cropping and/or finances	4	3	21.8(±5.3)	4.75(±5.91)	5.50(±3.70)	23.5(±5.4)
Time with animals			P = 0.9	P = 0.7	P = 0.9	P = 0.9
0-20%	9	8	18.3(±5.7)	4.44(±4.16)	4.33(±2.87)	27.2(±7.7)
21-40%	23	20	16.4(±5.9)	5.61(±3.17)	5.83(±4.30)	28.4(±3.8)
41-60%	29	25	17.1(±7.6)	4.10(±4.13)	5.28(±4.34)	27.8(±6.4)
61-80%	27	23.5	17.1(±7.0)	4.85(±4.72)	5.37(±5.65)	28.4(±7.1)
81-100%	27	23.5	18.1(±7.0)	5.41(±4.84)	4.74(±3.43)	28.1(±5.9)

Table 2.5 Comparing farm responsibilities variables to physical health outcomes

Variable	Getting enough sleep		Sleeping hours		
	No	Yes	7-8 hours	5-6 hours	Less than 5hours
Time alone	P = 0.3		P = 0.3		
0-20%	3%	3%	3%	3%	0%
21-40%	11%	5%	3%	12%	1%
41-60%	17%	13%	17%	19%	2%
61-80%	16%	21%	21%	14%	3%
81-100%	7%	3%	4%	4%	1%
Tasks	P = 0.7		P = 0.7		
Animal care, cleaning, cropping and finances	4%	3%	0%	6%	1%
Animal care, cleaning, cropping, finances and milking	23%	16%	15%	21%	3%
Animal care, cleaning, cropping and milking	11%	9%	10%	10%	0%
Animal care, cleaning, finances and milking	3%	6%	5%	3%	1%
Animal care, cleaning and milking	6%	6%	5%	6%	1%
Animal care, cropping, finances	5%	3%	4%	4%	0%
Cropping and/or finances	3%	1%	2%	2%	0%
Time with animals	P = 0.6		P = 0.07		
0-20%	5%	3%	3%	4%	0%
21-40%	13%	7%	11%	8%	1%
41-60%	12%	13%	17%	8%	0%
61-80%	11%	12%	13%	10%	1%
81-100%	14%	10%	8%	11%	5%

Table 2.6 Comparing work-life balance to mental health scores

Variable	Freq	%	Stress	Anxiety	Depression	Resilience
Healthy work life balance			P<0.001	P=0.1	P=0.1	P< 0.001
Yes	35	31	13.8(±6.4)	3.6(±4.6)	4.3(±5.0)	30.5(±7.0)
Sometimes	60	53	18.2(±6.0)	5.3(±4.1)	5.0(±3.8)	27.5(±5.0)
No	19	17	21.0(±7.1)	6.1(±3.7)	7.4(±4.3)	25.4(±5.8)
Time for rest			P=0.8	P=0.8	P=0.9	P=0.01
Everyday	6	5	19.8(±7.4)	5.17(±5.60)	5.67(±2.16)	26.2(±7.3)
Nearly everyday	25	22	14.9(±6.9)	4.48(±4.30)	5.08(±4.74)	31.6(±6.6)
A few times during the week	58	51	17.0(±6.4)	4.74(±3.64)	5.09(±3.56)	27.5(±5.2)
Once per week	13	11	18.7(±5.7)	5.69(±6.22)	6.08(±6.78)	28.1(±5.2)
Less than once per week	13	11	20.8(±7.6)	5.62(±4.27)	4.92(±5.06)	25.2(±6.7)
Number of days work/ week			P =0.2	P=0.5	P=0.07	P=0.9
Everyday	88	77	16.8(±7.0)	4.65(±3.81)	4.75(±3.97)	28.2(±6.0)
6 days or less	27	23	18.9(±5.3)	5.73(±5.57)	6.54(±5.24)	27.9(±6.3)
Vacation time			P=0.2	P=0.2	P=0.3	P=0.4
None at all	12	11	15.6(±9.1)	3.67(±9.1)	3.58(±3.29)	29.3(±5.5)
1-2 days	16	14	16.1(±7.1)	3.81(±2.95)	4.19(±4.32)	28.3(±6.8)
3-6 days	16	14	19.8(±8.5)	6.25(±4.78)	6.56(±4.40)	26.1(±5.9)
One week	23	20	16.3(±7.7)	5.61(±4.06)	5.26(±4.75)	29.1(±6.9)
2 weeks	28	24	19.3(±4.7)	5.64(±5.52)	6.14(±5.09)	26.9(±5.1)
More than 3 weeks	20	17	15.7(±5.3)	3.65(±2.91)	4.55(±5.98)	29.4(±6.0)

Table 2.7 Comparing work-life balance to physical health outcomes

Variable	Getting enough sleep		Sleeping hours		
	No	Yes	7-8 hours	5-6 hours	Less than 5hours
Healthy work life balance	P<0.001		P=0.2		
yes	10%	21%	15%	15%	1%
Sometimes	32%	20%	23%	25%	3%
No	14%	3%	3%	12%	2%
Time for rest	P=0.07		P=0.5		
Everyday	1%	4%	3%	2%	0%
Nearly everyday	10%	12%	10%	11%	0%
A few times during the week	29%	22%	23%	24%	3%
Once per week	8%	3%	3%	8%	0%
Less than once per week	9%	3%	1%	8%	3%
Number of days work/ week	P=0.2		P=0.6		
Everyday	40%	36%	32%	14%	5%
6 days or less	16%	7%	8%	39%	1%
Vacation time	P=0.6		P=0.2		
None at all	5%	5%	1%	8%	2%
1-2 days	6%	8%	7%	6%	1%
3-6 days	10%	4%	4%	9%	1%
One week	13%	7%	7%	13%	0%
2 weeks	14%	10%	14%	9%	2%
More than 3 weeks	8%	10%	8%	9%	1%

Table 2.8 Comparing social environment variables and mental health scores

Variable	Freq	%	Stress	Anxiety	Depression	Resilience
Total workers			P=0.1	P=0.2	P=0.3	P=0.07
Who works on the farm			P=0.3	P=0.006	P=0.01	P=0.8
Employees	4	4	20.8(±5.2)	9.75(±7.5)	11.5(±9.3)	28.3(±8.3)
Family members	39	34	16.1(±7.0)	3.95(±2.59)	4.28(±3.42)	28.1(±5.9)
Family members and employees	71	62	17.7(±6.7)	5.04(±4.51)	5.34(±4.24)	28.2(±6.1)
Someone to talk to at work			P=0.1	P=0.004	P=0.07	P=0.4
Yes	95	83	16.7(±6.8)	4.4(±4.0)	4.79(±4.44)	28.4(±5.5)
No	20	17	19.8(±6.2)	7.0(±4.5)	7.21(±4.44)	26.7(±5.5)
Satisfied with the support at home			P<0.001	P<0.001	P=0.003	P=0.02
Very satisfied	22	19	14.9(±6.6)	3.60(±3.21)	4.03(±4.69)	30.4(±5.2)
Satisfied	48	42	15.3(±6.0)	3.55(±2.66)	4.17(±3.41)	28.4(±5.5)
Neutral	33	29	21.4(±5.6)	6.92(±5.18)	7.00(±4.16)	26.3(±6.4)
Dissatisfied	7	6	22.7(±7.3)	8.57(±3.21)	7.57(±3.69)	26.1(±7.0)
Very dissatisfied	2	2	22.2(±7.3)	8.60(±3.71)	9.60(±5.55)	22.8(±8.3)
Not applicable	2	2	22.0	14.0	7.00	23.0
Satisfied with the support at work			P=0.08	P=0.5	P=0.9	P=0.01
Very satisfied	22	19	13.9(±7.2)	3.7(±4.8)	4.00(±4.3)	31.5(±5.3)
Satisfied	48	42	16.3(±6.3)	4.40(±3.8)	5.00(±3.86)	28.3(±5.8)
Neutral	33	28	20.1(±6.0)	5.50(±3.6)	5.50(±3.87)	26.6(±5.8)
Dissatisfied	7	6	22.3(±4.7)	9.1(±5.1)	9.90(±4.30)	22.7(±6.8)
Very dissatisfied	2	2	18.5(±10.6)	5.5(±3.5)	7.00(±7.07)	29.0(±5.7)
Not applicable	3	3	15.3(±6.5)	5.0(±7.8)	3.00(±3.61)	28.3(±4.7)
Satisfied with your veterinarian			P=0.6	P=0.2	P=0.2	P=0.3
Very satisfied	60	52	17.1(±7.5)	4.93(±4.05)	5.13(±4.0)	28.3(±6.2)
Satisfied	35	30	16.4(±6.1)	3.89(±3.04)	4.23(±3.96)	28.3(±4.9)

Neutral	3	3	18.3(±4.2)	5.00(±2.0)	6.33(±1.15)	21.0(±2.6)
Dissatisfied	1	1	17.0	7.00	10.0	34.0
Very dissatisfied	0	0	-	-	-	-
Not applicable	16	14	19.8(±5.1)	6.94(±6.69)	7.13(±6.11)	27.9(±7.6)
Satisfied with nutritionist			P=0.02	P=0.07	P=0.04	P=0.02
Very satisfied	57	50	15.9(±7.2)	4.49(±4.37)	4.44(±4.55)	29.7(±4.9)
Satisfied	40	35	17.9(±5.7)	4.55(±2.99)	5.38(±3.55)	26.6(±4.9)
Neutral	2	2	23.5(±13.4)	8.50(±0.71)	10.5(±4.9)	25.5(±4.9)
Dissatisfied	0	0	-	-	-	-
Very dissatisfied	0	0	-	-	-	-
Not applicable	15	13	20.9(±4.8)	7.33(±5.9)	7.33(±4.61)	25.5(±7.6)
Satisfied with equipment supplier			P=0.3	P=0.6	P=0.02	P=0.3
Very satisfied	23	20	15.4(±7.7)	4.0(±5.0)	4.1(±2.9)	29.2(±5.3)
Satisfied	34	30	16.3(±7.4)	4.2(±4.2)	3.7(±4.1)	28.4(±6.1)
Neutral	8	7	16.8(±5.7)	5.4(±5.8)	5.3(±4.4)	27.4(±6.1)
Dissatisfied	5	4	17.8(±3.8)	7.0(±4.9)	8.2(±4.0)	28.4(±6.9)
Very dissatisfied	1	1	26.0	8.0	12.0	25.0
Not applicable	44	38	18.9(±6.0)	5.6(±4.5)	6.5(±4.8)	27.7(±6.6)
Value by the dairy industry			P=0.5	P=0.3	P=0.4	P=0.4
Extremely valued	12	10	16.6(±6.0)	4.50(±5.81)	5.08(±6.52)	31.2(±5.5)
Very valued	25	22	16.6(±6.3)	4.28(±4.15)	4.68(±4.19)	28.8(±4.5)
Moderately valued	43	37	16.6(±6.0)	4.53(±3.55)	4.63(±3.77)	27.7(±6.4)
Slightly valued	17	15	18.8(±8.8)	4.88(±3.77)	5.71(±3.75)	26.1(±6.1)
Not at all valued	17	15	18.7(±7.6)	7.00(±5.17)	6.71(±4.69)	28.0(±7.2)
Not applicable	1	1	26.0	7.00	11.0	27.0
Valued by consumers			P<0.001	P<0.001	P=0.001	P=0.005
Extremely valued	2	2	16.0(±15.6)	10.5(±14.8)	12.0(±17.0)	37.5(±3.5)
Very valued	22	19	13.2(±6.0)	2.18(±2.02)	2.91(±2.71)	30.6(±4.5)
Moderately valued	54	47	16.6(±6.0)	4.26(±3.77)	4.83(±4.04)	28.3(±6.3)

Slightly valued	25	22	20.0(±6.4)	6.36(±3.81)	6.36(±3.73)	25.6(±5.8)
Not at all valued	12	10	22.6(±6.1)	8.92(±3.85)	7.58(±4.29)	26.1(±5.4)
Not applicable	0	0	-	-	-	-

Table 2.9 Comparing social environment variables to physical health outcomes

Variable	Getting enough sleep		Sleeping hours		
Total workers	0.002		0.9		
	No	Yes	7-8 hours	5-6 hours	Less than 5hours
Who works on the farm	P=0.5		P=0.004		
Employees	3%	1%	3%	1%	0%
Family members	16%	17%	13%	20%	1%
Family members and employees	35%	26%	25%	32%	4%
Someone to talk to at work	P =0.1		P<0.001		
Yes	43%	40%	9%	47%	3%
No	12%	4%	32%	6%	2%
Blank	1%		0%	0%	1%
Satisfied with the support at home	P=0.1		P=0.6		
Very satisfied	12%	18%	11%	16%	3%
Satisfied	22%	15%	12%	24%	0%
Neutral	13%	9%	13%	7%	2%
Dissatisfied	3%	3%	3%	3%	0%
Very dissatisfied	4%	0%	2%	2%	1%
Not applicable	1%	0%	0%	0%	1%
Satisfied with the support at work	P=0.9		P=0.3		
Very satisfied	8%	11%	7%	7%	2%
Satisfied	24%	17%	2%	22%	2%
Neutral	17%	11%	2%	15%	2%
Dissatisfied	3%	3%	3%	3%	0%
Very dissatisfied	2%	0%	1%	1%	0%

Not applicable		1%	2%	0%	2%	1%
Satisfied with your veterinarian		P=0.8		P=0.6		
Very satisfied		30%	23%	21%	29%	3%
Satisfied		16%	14%	11%	16%	3%
Neutral		1%	2%	2%	1%	0%
Dissatisfied		1%	0%	0%	0%	0%
Very dissatisfied		30%	23%	0%	0%	0%
Not applicable		8%	6%	7%	5%	1%
Satisfied with nutritionist		P=0.2		P=0.7		
Very satisfied		24%	25%	19%	28%	3%
Satisfied		2%	15%	16%	17%	2%
Neutral		2%	0%	0%	2%	0%
Dissatisfied		0%	0%	0%	0%	0%
Very dissatisfied		0%	0%	0%	0%	0%
Not applicable		10%	3%	6%	5%	2%
Satisfied with equipment supplier		P=0.2		P=0.3		
Very satisfied		8%	1%	8%	12%	0%
Satisfied		15%	15%	2%	20%	2%
Neutral		3%	3%	2%	2%	2%
Dissatisfied		3%	1%	0%	0%	0%
Very dissatisfied		1%	0%	0%	0%	0%
Not applicable		23%	13%	3%	3%	3%
Value by the dairy industry		P=0.6		P=0.4		
Extremely valued		7%	3%	3%	8%	0%
Very valued		14%	8%	7%	14%	1%
Moderately valued		19%	18%	3%	16%	3%
Slightly valued		7%	8%	0%	8%	0%
Not at all valued		9%	6%	2%	8%	0%
Not applicable		0%	1%	0%	0%	0%

Valued by consumers	P=0.1		P=0.8		
Extremely valued	2%	0%	0%	2%	0%
Very valued	7%	12%	6%	12%	1%
Moderately valued	26%	21%	3%	23%	3%
Slightly valued	13%	9%	1%	10%	1%
Not at all valued	8%	3%	1%	6%	1%
Not applicable	0%	0%	0%	0%	0%

Table 2.10 Comparing housing and animal management to mental health scores

Variable	Freq	%	Stress	Anxiety	Depression	Resilience
Milking system			P=0.3	P=0.8	P=0.8	P=0.9
AMS	47	41	16.5(±7.3)	5.02(±3.82)	5.06(±3.93)	28.1(±6.4)
Conventional	68	59	17.8(±6.3)	4.84(±4.56)	5.31(±4.65)	28.1(±5.8)
State of the barn			P=0.06	P=0.5	P=0.7	P=0.3
New construction	34	30	15.0(±7.1)	4.68(±4.76)	5.41(±5.26)	29.6(±5.3)
Original construction	52	45	18.1(±6.6)	5.06(±3.86)	5.12(±4.09)	27.7(±4.1)
Retrofit	18	16	16.9(±6.8)	4.00(±3.34)	4.39(±4.07)	26.9(±4.1)
Other	11	9	21.09	6.45(±5.68)	6.36(±2.84)	27.0(±2.8)
Housing			P=0.5	P=0.1	P=0.002	P=0.5
Bedded pack	8	7	20.0(±5.4)	7.88(±6.40)	10.1(±7.1)	28.9(±5.4)
Free stall	91	79	17.1(±6.8)	4.67(±4.06)	4.69(±3.80)	28.3(±6.2)
Tie stall	16	14	17.4(±7.3)	4.81(±3.80)	5.69(±4.38)	26.5(±5.6)
Stall base			P=0.3	P=0.09	P=0.06	P=0.8
Concrete	76	66	16.9(±7.1)	4.41(±4.04)	4.66(±4.24)	28.2(±4.2)
Deep bedded	39	34	18.2(±5.9)	5.90(±4.55)	6.28(±4.41)	27.9(±4.4)
Secondary base			P=0.6	P=0.4	P=0.3	P=0.9
Compost	6	5	18.5(±4.7)	5.50(±2.74)	8.67(±3.73)	28.2(±5.0)
Concrete	1	1	29.0	10.0	6.00	28.0
Mattress	49	42	17.0(±7.4)	4.76(±4.38)	5.16(±4.87)	28.3(±5.5)
Mattress + Water beds	6	5	16.5(±7.1)	4.00(±4.90)	4.50(±3.33)	28.8(±7.9)
Sand	32	28	18.0(±6.0)	5.94(±4.80)	5.78(±4.29)	28.2(±7.0)
Straw or sawdust	10	9	15.5(±6.2)	3.70(±2.63)	3.50(±3.80)	26.9(±7.1)
Water beds	11	10	17.0(±7.3)	3.45(±3.24)	3.73(±2.37)	27.4(±5.0)
Bedding			P=0.7	P=0.1	P=0.06	P=0.9
Inorganic	27	23	17.8(±6.1)	5.78(±5.11)	5.26(±4.23)	28.6(±7.3)
Organic	85	74	17.0(±6.9)	4.51(±3.94)	4.99(±4.33)	27.9(±5.6)
Organic + Inorganic	3	3	20.0(±7.9)	8.67(±1.53)	11.0(±2.6)	28.0(±6.6)

Table 2. 11 Comparing housing and animal management to physical health outcomes

Variable	Getting enough sleep		Sleeping hours		
	No	Yes	7-8 hours	5-6 hours	Less than 5 hours
Milking system	P=0.1		P=0.07		
AMS	19%	22%	22%	16%	3%
Conventional	36%	23%	19%	36%	3%
State of the barn	P=0.8		P=0.2		
New construction	15%	15%	11%	2%	2%
Original construction	26%	19%	16%	27%	2%
Retrofit	9%	7%	7%	8%	1%
Other	6%	3%			
Housing	P=0.2		P=0.8		
Bedded pack	5%	2%	3%	4%	0%
Free stall	41%	38%	34%	40%	5%
Tie stall	9%	4%	4%	9%	1%
Stall base	0.6		0.8		
Concrete	36%	30%	26%	36%	3%
Deep bedded	20%	14%	15%	16%	3%
Secondary base	P=0.5		P=0.8		
Compost	4%	1%	1%	4%	0%
Concrete	1%	0%	0%	1%	0%
Mattress	25%	17%	16%	24%	2%
Mattress + Water beds	2%	3%	4%	2%	0%
Sand	16%	12%	13%	12%	3%
Straw or sawdust	3%	5%	3%	4%	1%
Water beds	4%	5%	3%	5%	1%
Bedding	P=0.9		P=0.3		
Inorganic	13%	10%	12%	9%	3%
Organic	41%	33%	28%	43%	3%
Organic + Inorganic	2%	1%	1%	2%	0%

Table 2.12 Comparing sleep quality to mental health outcomes

Variable	Freq	%	Stress	Anxiety	Depression	Resilience
Sleep hours			P = 0.9	P= 0.1	P =0.9	P=0.7
Less than 5 hours	7	6	18.4(±5.5)	7.86(±5.64)	5.43(±3.82)	28.4(±6.3)
5-6 hours	61	53	17.0(±7.5)	4.52(±4.30)	5.31(±4.91)	28.5(±6.1)
7-8 hours	47	41	17.5(±6.0)	4.98(±3.89)	5.04(±3.67)	27.5(±5.9)
Getting enough sleep			P<0.001	P<0.001	P<0.001	P=0.06
Yes	51	44	19.4(±6.0)	5.86(±4.80)	6.61(±4.86)	27.1(±5.9)
No	64	56	14.8(±6.9)	3.76(±3.14)	3.46(±2.82)	29.3(±6.1)

Figure 2.4 Cause of injuries among surveyed farmers

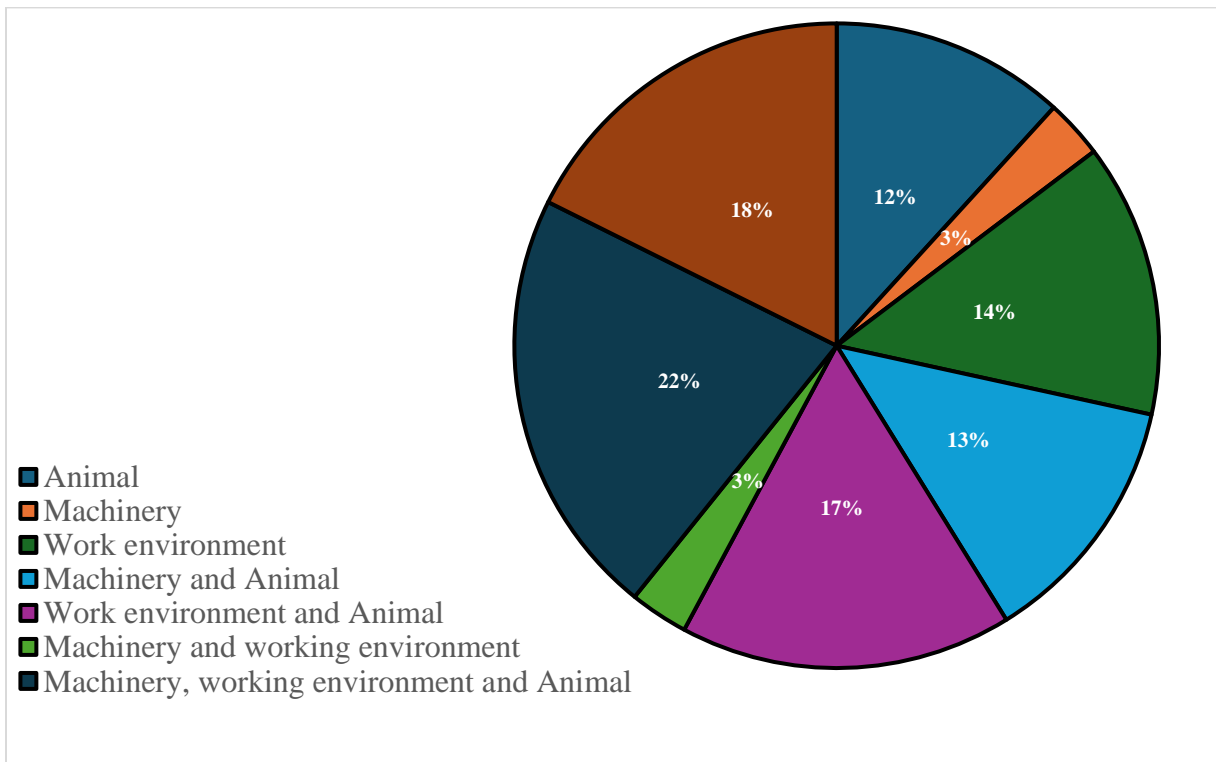


Figure 2.5 Reported injuries and health problems sustained while working on the farm

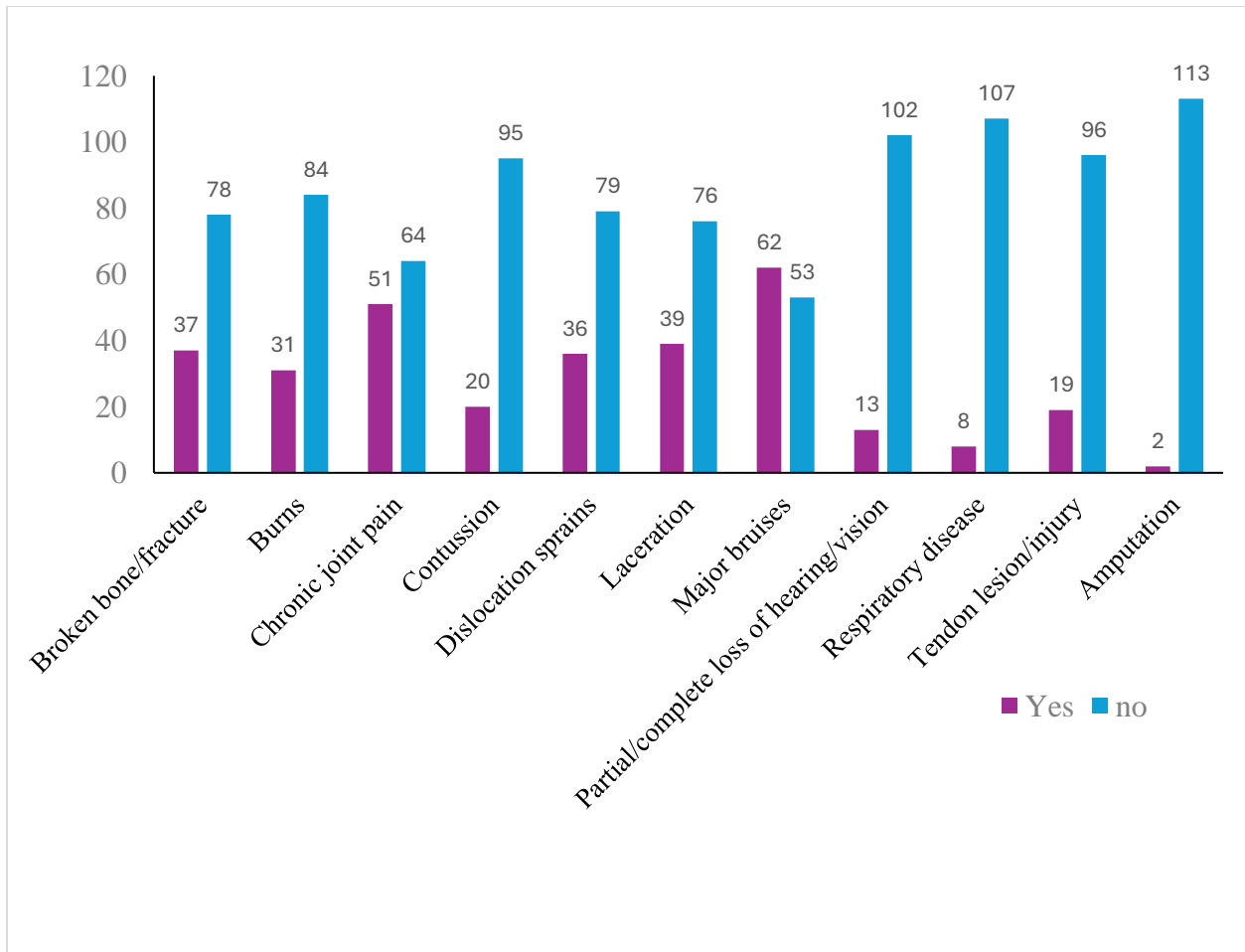


Table 2.13 Comparing specific stressors to mental health scores

Variable	Freq	%	Stress	Anxiety	Depression	Resilience
Animal health and or welfare			P=0.04	P<0.001	P=0.003	P=0.01
Never	20	17	15.4(±7.9)	3.15(±3.54)	3.65(±3.27)	30.1(±4.8)
Almost never	39	34	15.3(±5.6)	3.28(±3.39)	3.90(±3.70)	29.8(±5.4)
Sometimes	33	29	19.2(±5.5)	6.55(±4.21)	6.36(±4.28)	26.4(±6.0)
Fairly often	14	12	18.7(±8.5)	5.64(±3.63)	5.71(±3.41)	25.5(±3.9)
Very often	7	6	20.1(±7.6)	8.71(±6.07)	9.86(±7.78)	28.0(±10.8)
Not applicable	2	2	24.50(±2.12)	9.00(±5.66)	7.50(±3.54)	20.0(±5.66)
Drought			P=0.2	P=0.03	P=0.08	P=0.04
Never	49	43	17.4 (±5.9)	4.35(±3.29)	5.22(±3.68)	28.2(±5.2)
Almost never	15	13	20.4(±6.2)	6.27(±5.09)	6.53(±4.55)	24.0(±6.5)
Sometimes	27	23	15.3(±6.4)	3.41(±3.34)	3.63(±3.26)	30.2(±5.5)
Fairly often	11	10	17.2(±8.0)	6.09(±4.41)	4.36(±4.80)	26.6(±8.6)

Very often	11	10	16.6(±9.4)	7.55(±6.87)	7.91(±7.29)	29.4(±5.8)
Not applicable	2	1	24.0(±7.1)	8.00(±2.83)	6.00(±0)	30.00
Flooding			P=0.4	P=0.03	P=0.002	P=0.5
Never	76	66	16.6(±6.8)	4.30(±3.62)	4.83(±4.02)	27.8(±5.7)
Almost never	22	19	18.1(±5.7)	6.23(±4.87)	5.86(±4.04)	27.8(±7.3)
Sometimes	8	7	19.1(±7.9)	5.00(±5.24)	4.63(±4.87)	28.0(±6.2)
Fairly often	3	3	19.0(±5.0)	4.67(±3.06)	5.00(±1.73)	29.3(±2.1)
Very often	2	2	25.5(±2.1)	13.5(±10.6)	17.5(±9.2)	33.0(±9.9)
Not applicable	4	3	17.0(±9.6)	5.00	4.00(±2.45)	33.0(±3.9)
Energy pricing			P=0.09	P=0.02	P=0.1	P=0.9
Never	16	14	16.2(±6.6)	3.76(±3.38)	4.34(±3.52)	27.8(±5.6)
Almost never	14	12	17.7(±6.7)	4.73(±5.7)	5.46(±4.73)	28.3(±6.1)
Sometimes	36	31	16.5(±6.7)	4.82(±4.2)	4.24(±3.47)	27.3(±5.8)
Fairly often	20	17	16.5(±7.0)	5.12(±4.54)	6.24(±4.39)	28.9(±7.6)
Very often	28	24	24.1(±4.3)	10.0(±6.3)	9.13(±7.22)	30.1(±5.5)
Not applicable	1	1	19.0	6.00	6.00	32.0
Farm finance			P<0.001	P<0.001	P<0.001	P=0.4
Never	16	14	13.1(±7.2)	2.25(±3.0)	3.06(±3.77)	30.4(±7.5)
Almost never	14	12	12.9(±6.3)	2.93(±2.62)	3.36(±3.69)	29.3(±5.4)
Sometimes	36	31	17.1(±6.1)	4.14(±3.03)	4.50(±3.53)	27.4(±4.8)
Fairly often	20	18	18.1(±5.1)	5.10(±3.92)	4.60(±3.44)	28.2(±6.7)
Very often	28	24	21.5(±6.2)	8.25(±5.18)	8.68(±4.81)	26.9(±6.3)
Not applicable	1	1	19.0	6.00	6.00	32.0
Feed availability			P=0.04	P=0.001	P=0.03	P=0.7
Never	39	34	15.7(±7.09)	3.69(±4.16)	4.36(±4.08)	29.0(±6.2)
Almost never	31	27	17.0(±6.6)	4.55(±3.55)	5.19(±4.25)	27.6(±6.5)
Sometimes	23	20	16.6(±6.4)	4.91(±3.64)	4.30(±3.70)	27.6(±4.8)
Fairly often	12	10	19.9(±5.1)	6.17(±4.26)	6.67(±3.89)	27.2(±5.9)
Very often	7	6	24.4(±6.0)	11.3(±5.3)	10.4(±6.5)	30.1(±6.6)
Not applicable	3	3	21.0(±2.8)	5.50(±0.71)	5.50(±0.71)	24.0(±11.3)
Feed cost			P=0.02	P<0.001	P=0.02	P=0.7
Never	12	10	15.6(±6.0)	2.50(±2.15)	3.83(±3.07)	29.7(±4.9)
Almost never	19	16	15.9(±5.8)	3.32(±2.50)	4.37(±4.40)	28.5(±4.9)
Sometimes	35	30	16.1(±7.5)	4.71(±3.75)	5.11(±4.11)	28.4(±6.7)
Fairly often	25	22	17.1(±4.8)	4.44(±3.82)	4.24(±3.43)	26.9(±5.4)
Very often	24	21	21.3(±7.3)	8.17(±5.49)	7.71(±5.28)	27.8(±7.0)
Not applicable	-	-				
Human resource management*			P=0.005	P=0.008	P=0.006	P=0.7
Never	36	31	14.9(±7.0)	3.33(±3.51)	3.64(±3.37)	28.7(±6.2)
Almost never	16	14	15.4(±4.8)	3.31(±2.87)	5.06(±4.34)	28.2(±5.9)
Sometimes	33	29	18.3(±6.8)	5.76(±4.30)	5.33(±4.40)	27.6(±6.4)
Fairly often	10	9	21.60(±5.8)	6.40(±3.86)	6.90(±3.84)	26.3(±5.0)
Very often	11	10	21.7(±5.2)	8.18(±6.63)	9.45(±5.99)	28.5(±5.9)

Not applicable	9	8	17.6(±6.7)	5.63(±2.45)	4.38(±2.39)	28.6(±6.6)
Learning and implementing new technology			P=0.08	P<0.001	P=0.1	P=0.04
Never	46	40	15.4(±7.1)	3.67(±3.4)	4.87(±3.92)	29.4(±5.3)
Almost never	25	22	18.5(±6.8)	5.24(±4.1)	4.92(±3.96)	27.5(±5.7)
Sometimes	19	16	17.0(±5.1)	4.42(±3.08)	3.95(±3.29)	27.9(±5.1)
Fairly often	11	10	19.0(±6.0)	4.36(±3.85)	6.18(±5.15)	22.8(±7.3)
Very often	6	5	22.8(±4.3)	10.0(±6.8)	9.50(±8.04)	29.2(±6.7)
Not applicable	8	7	18.9(±8.0)	9.13(±5.38)	6.50(±4.41)	29.1(±8.1)
Marketing and milk prices			P=0.001	P<0.001	P=0.01	P=0.7
Never	28	25	14.6(±7.8)	3.75(±3.58)	3.93(±4.29)	28.7(±6.3)
Almost never	26	23	16.5(±5.8)	4.19(±3.70)	4.77(±3.70)	28.4(±5.4)
Sometimes	28	25	16.8(±5.8)	4.14(±3.84)	4.39(±3.45)	28.7(±6.0)
Fairly often	17	15	18.0(±5.3)	5.29(±4.18)	6.24(±4.62)	25.9(±6.4)
Very often	13	12	23.1(±5.5)	8.77(±5.29)	8.69(±5.66)	28.1(±6.6)
Not applicable	0	0				
Pasture condition			P=0.5	P=0.2	P=0.1	P=0.7
Never	53	47	17.3(±7.3)	4.64(±4.02)	5.43(±4.04)	28.4(±5.8)
Almost never	16	14	16.8(±6.3)	4.56(±4.18)	4.63(±4.13)	28.4(±5.4)
Sometimes	13	12	17.6(±5.2)	4.46(±3.78)	3.54(±2.40)	28.2(±4.8)
Fairly often	2	2	12.5(±7.8)	1.50(±2.12)	0.00(±2.40)	33.5(±4.9)
Very often	2	3	18.7(±7.4)	8.33(±10.97)	9.67(±12.7)	31.0(±7.8)
Not applicable	25	22	16.7(±6.4)	5.16(±3.97)	5.56(±4.45)	26.6(±7.3)
Personal finances			P<0.001	P<0.001	P<0.001	P=0.07
Never	35	31	13.9(±7.3)	2.03(±4.02)	2.63(±4.04)	30.0(±5.8)
Almost never	21	18	16.9(±6.3)	5.43(±4.18)	5.10(±4.13)	29.1(±5.4)
Sometimes	22	19	17.4(±5.2)	5.59(±3.78)	5.14(±2.40)	28.2(±4.8)
Fairly often	16	14	19.1(±7.8)	4.50(±2.12)	6.44(±0.00)	24.7(±4.9)
Very often	14	12	23.6(±7.4)	10.6(±11.0)	10.6(±7.8)	26.6(±7.8)
Not applicable	7	6	17.8(±6.4)	5.33(±3.97)	5.50(±4.45)	25.3(±7.3)
Policy and regulations			P<0.001	P<0.001	P<0.001	P=0.7
Never	22	19	13.3(±7.6)	2.59(±2.82)	2.86(±3.15)	29.9(±4.7)
Almost never	20	17	17.7(±5.3)	5.55(±3.78)	5.25(±3.37)	28.0(±6.2)
Sometimes	41	36	17.8(±5.9)	4.56(±3.35)	5.63(±3.86)	28.0(±5.2)
Fairly often	17	15	17.1(±7.4)	5.00(±4.62)	5.59(±4.70)	27.3(±7.27)
Very often	10	9	24.8(±2.2)	10.8(±6.0)	9.00(±7.15)	25.8(±8.0)
Not applicable	5	4	16.0(±6.2)	3.75(±2.63)	3.75(±2.22)	27.7(±9.9)
Public perceptions			P=0.2	P=0.008	P=0.08	P=0.5
Never	31	27	14.8(±6.9)	3.23(±2.74)	3.26(±2.78)	29.2(±4.4)
Almost never	29	25	17.3(±6.4)	4.69(±3.85)	5.76(±4.27)	28.2(±6.71)

Sometimes	26	23	18.3(±6.4)	4.81(±3.64)	5.62(±4.30)	27.0(±6.0)
Fairly often	14	12	17.7(±7.2)	6.14(±4.75)	5.71(±3.73)	26.4(±5.45)
Very often	13	11	20.8(±6.8)	8.54(±6.46)	7.46(±6.84)	29.4(±8.3)
Not applicable	2	2	14.0	1.00	2.00	21.00
Weather			P=0.4	P=0.06	P=0.3	P=0.7
Never	15	13	16.4(±6.7)	2.67(±2.23)	3.93(±3.31)	29.7(±4.5)
Almost never	15	13	15.9(±6.5)	3.53(±3.62)	3.93(±3.06)	28.3(±6.6)
Sometimes	38	33	16.9(±6.7)	5.03(±3.89)	5.05(±4.07)	27.4(±6.5)
Fairly often	28	24	17.2(±7.5)	5.93(±4.61)	5.96(±4.55)	27.6(±6.1)
Very often	19	17	20.0(±5.8)	6.05(±5.37)	6.42(±5.82)	28.8(±5.9)
Not applicable	0	0				
Wild fires			P=0.2	P<0.001	P=0.003	P=0.5
Never	68	59	16.6(±6.9)	4.41(±3.77)	5.13(±4.18)	27.8(±5.7)
Almost never	17	15	16.7(±5.0)	4.65(±3.81)	4.29(±3.42)	29.3(±6.7)
Sometimes	15	13	18.4(±8.2)	4.93(±4.54)	4.13(±4.12)	26.6(±7.5)
Fairly often	1	1	23.0	7.00	7.00	22.0
Very often	5	4	24.2(±4.1)	13.4(±5.4)	12.8(±6.8)	31.2(±6.1)
Not applicable	9	8	17.6(±6.0)	4.22(±3.27)	4.89(±2.67)	29.6(±4.1)
Workload			P<0.001	P<0.001	P<0.001	P=0.009
Never	10	9	11.3(±5.2)	1.40(±1.78)	2.50(±2.64)	32.1(±6.6)
Almost never	15	13	11.7(±3.9)	2.00(±2.65)	2.00(±1.65)	31.9(±5.4)
Sometimes	35	31	15.7(±5.9)	4.17(±3.02)	4.69(±3.87)	28.1(±4.6)
Fairly often	28	24	19.5(±5.6)	5.96(±4.46)	5.79(±4.16)	27.0(±6.6)
Very often	25	22	22.8(±5.4)	7.72(±4.74)	8.12(±4.88)	25.6(±5.9)
Not applicable	1	1	26.0	12.0	12.0	22.0
Continuation of Quota			P=0.1	P=0.003	P=0.05	P=0.6
Never	33	29	15.0(±7.2)	3.48(±3.33)	3.79(±3.19)	29.5(±5.2)
Almost never	28	25	17.2(±6.8)	5.11(±4.11)	5.54(±4.22)	27.5(±6.4)
Sometimes	33	29	18.9(±5.8)	5.00(±3.54)	5.82(±4.26)	27.3(±5.3)
Fairly often	8	7	15.0(±6.1)	3.25(±3.85)	3.50(±3.89)	28.9(±6.6)
Very often	9	8	20.7(±7.8)	10.0(±7.0)	8.89(±7.30)	27.0(±9.1)
Not applicable	2	2	20.0(±4.2)	7.50(±3.54)	5.50(±0.71)	24.5(±12.0)
Value of Quota			P=0.9	P=0.2	P=0.5	P=0.7
Never	26	23	17.0(±6.9)	3.65(±3.33)	5.31(±3.65)	27.8(±5.21)
Almost never	20	17	16.4(±6.1)	5.00(±3.73)	4.65(±3.30)	29.0(±6.30)
Sometimes	43	37	17.8(±7.1)	4.77(±3.83)	4.79(±4.38)	27.8(±6.22)
Fairly often	12	11	18.2(±5.4)	5.25(±4.39)	5.00(±3.77)	26.4(±5.18)
Very often	13	11	16.8(±8.3)	7.38(±6.89)	7.38(±6.96)	29.5(±7.63)
Not applicable	1	1	19.0	6.00	6.00	32.0
Raw milk prices			P=0.6	P=0.006	P=0.008	P=0.7
Never	30	26	16.3(±7.6)	4.57(±3.95)	4.67(±3.70)	27.5(±4.7)
Almost never	27	23	17.5(±6.5)	4.30(±4.04)	5.07(±3.98)	28.6(±7.3)
Sometimes	37	32	17.2(±6.5)	4.11(±3.16)	4.08(±3.68)	28.3(±6.04)
Fairly often	10	9	16.4(±6.2)	5.60(±5.34)	6.80(±4.94)	25.7(±7.15)
Very often	10	9	20.9(±6.4)	9.80(±5.67)	9.70(±6.31)	29.7(±5.0)

Not applicable	1	1	19.00	6.00	6.00	32.00
Animal rights activists			P=0.05	P=0.002	P=0.05	P=0.1
Never	32	28	15.4(±7.6)	3.91(±3.34)	3.69(±2.95)	28.1(±5.7)
Almost never	38	33	16.2(±5.73)	3.66(±3.15)	4.66(±3.97)	28.9(±5.4)
Sometimes	27	24	19.4(±6.4)	6.15(±4.72)	6.48(±4.57)	25.9(±7.3)
Fairly often	9	8	17.2(±7.03)	5.33(±3.91)	6.44(±4.30)	27.7(±4.9)
Very often	6	5	22.5(±5.6)	10.5(±7.2)	9.00(±8.29)	33.7(±4.5)
Not applicable	2	2	25.0 (±1.4)	9.00(±5.66)	5.50(±6.36)	24.5(±0.71)

Table 2.14 Comparing specific stressors to physical health outcomes

Variable	Getting enough sleep		Sleeping hours		
	No	Yes	7-8 hours	5-6 hours	Less than 5hours
Animal health and or welfare	P=0.2		P=0.02		
Never	11%	11%	4%	10%	3%
Almost never	18%	16%	13%	20%	1%
Sometimes	13%	16^	15%	13%	1%
Fairly often	6%	6%	7%	4%	1%
Very often	6%	0%	0%	6%	0%
Not applicable	1%	1%	2%	0%	0%
Drought	P=0.3		P=0.7		
Never	28%	15%	16%	22%	4%
Almost never	9%	4%	4%	8%	1%
Sometimes	10%	13%	10%	13%	1%
Fairly often	3%	6%	6%	3%	0%
Very often	4%	5%	4%	5%	0%
Not applicable	1%	1%	0%	2%	0%
Flooding	P=0.8		P=0.9		
Never	37%	29%	29%	34%	5%
Almost never	10%	10%	7%	11%	1%
Sometimes	3%	3%	3%	3%	1%
Fairly often	2%	1%	2%	1%	0%
Very often	2%	0%	1%	1%	0%
Not applicable	2%	2%	1%	3%	0%
Energy pricing	P=0.3		P=0.9		
Never	13%	12%	11%	13%	1%
Almost never	14%	9%	8%	14%	1%
Sometimes	13%	16%	13%	13%	3%
Fairly often	9%	6%	5%	14%	1%
Very often	6%	1%	3%	3%	1%
Not applicable	1%	0%	0%	1%	0%
Farm finance	P=0.4		P=0.4		

Never		5%	7%	5%	8%	1%
Almost never		6%	7%	3%	8%	1%
Sometimes		18%	13%	13%	17%	1%
Fairly often		10%	8%	8%	8%	2%
Very often		16%	6%	11%	11%	2%
Not applicable		0%	1%	0%	1%	0%
Feed availability		P=0.3		P=0.4		
Never		20%	14%	8%	23%	3%
Almost never		16%	11%	13%	13%	1%
Sometimes		9%	11%	12%	7%	1%
Fairly often		7%	3%	5%	4%	1%
Very often		4%	2%	2%	4%	0%
Not applicable		0%	2%	2%	1%	0%
Feed cost		P=0.6		P=0.7		
Never		7%	3%	3%	7%	0%
Almost never		9%	8%	8%	9%	0%
Sometimes		15%	16%	11%	11%	2%
Fairly often		11%	10%	10%	10%	2%
Very often		14%	7%	8%	8%	3%
Not applicable		0%	0%	0%	0%	0%
Human resource management*		P<0.001		P=0.8		
Never		10%	22%	15%	16%	1%
Almost never		10%	4%	4%	10%	0%
Sometimes		19%	10%	11%	14%	3%
Fairly often		8%	1%	3%	4%	1%
Very often		8%	2%	3%	5%	1%
Not applicable		0%	1%	3%	3%	0%
Learning and implementing new technology		P=0.3		P=0.2		
Never		19%	21%	19%	21%	1%
Almost never		21%	10%	7%	7%	0%
Sometimes		10%	7%	7%	7%	3%
Fairly often		6%	3%	3%	4%	2%
Very often		5%	0%	2%	3%	0%
Not applicable		3%	3%	3%	3%	1%
Marketing and milk prices		P=0.8		P=0.3		
Never		11%	13%	6%	17%	1%
Almost never		14%	9%	8%	13%	1%
Sometimes		13%	11%	9%	11%	3%
Fairly often		10%	5%	8%	6%	0%
Very often		6%	5%	6%	4%	1%

Not applicable		0%	0%	0%	0%	0%
Pasture condition		P=0.6		P=0.8		
Never		26%	20%	18%	25%	3%
Almost never		9%	5%	5%	8%	1%
Sometimes		5%	6%	6%	3%	2%
Fairly often		0%	2%	1%	1%	0%
Very often		1%	2%	1%	2%	0%
Not applicable		13%	20%	8%	14%	0%
Personal finances		P=0.2		P=0.02		
Never		13%	17%	12%	17%	2%
Almost never		10%	8%	7%	7%	0%
Sometimes		14%	5%	7%	11%	2%
Fairly often		7%	7%	8%	6%	0%
Very often		9%	3%	6%	4%	2%
Not applicable		2%	3%	1%	4%	0%
Policy and regulations		P=0.2		P=0.8		
Never		9%	10%	6%	13%	0%
Almost never		11%	6%	6%	11%	1%
Sometimes		20%	16%	18%	16%	3%
Fairly often		9%	6%	5%	8%	2%
Very often		6%	3%	4%	3%	1%
Not applicable		0%	3%	2%	2%	0%
Public perceptions		P=0.5		P=0.08		
Never		13%	14%	9%	17%	1%
Almost never		15%	10%	10%	13%	2%
Sometimes		12%	10%	11%	10%	1%
Fairly often		6%	6%	6%	5%	1%
Very often		9%	3%	3%	7%	1%
Not applicable		1%		0%	0%	1%
Weather		P=0.3		P=0.4		
Never		8%	5%	4%	8%	0%
Almost never		7%	6%	7%	5%	1%
Sometimes		14%	19%	15%	15%	3%
Fairly often		16%	8%	10%	12%	2%
Very often		10%	6%	4%	12%	0%
Not applicable		0%	0%	0%	0%	0%
Wild fires		P=0.8		P=0.7		
Never		31%	28%	25%	30%	3%
Almost never		9%	6%	7%	6%	2%
Sometimes		9%	4%	3%	9%	1%
Fairly often		0%	1%	1%	0%	0%
Very often		3%	2%	3%	2%	0%
Not applicable		4%	3%	3%	6%	0%

Workload		P=0.002		P=0.002		
Never		5%	3%	1%	6%	2%
Almost never		4%	9%	6%	7%	0%
Sometimes		11%	19%	13%	16%	2%
Fairly often		15%	10%	15%	9%	1%
Very often		19%	3%	6%	15%	1%
Not applicable		1%	0%	0%	0%	1%
Continuation of Quota		P=0.6		P=0.1		
Never		14%	15%	10%	0%	1%
Almost never		16%	9%	6%	18%	2%
Sometimes		17%	11%	14%	13%	2%
Fairly often		3%	3%	3%	3%	1%
Very often		4%	3%	5%	3%	0%
Not applicable		0%	2%	2%	05	0%
Value of Quota		P=0.8		P=0.4		
Never		14%	9%	8%	14%	1%
Almost never		9%	9%	6%	10%	1%
Sometimes		21%	16%	15%	20%	3%
Fairly often		5%	5%	7%	2%	2%
Very often		7%	4%	5%	6%	0%
Not applicable		0%	1%	0%	1%	0%
Raw milk prices		P=0.8		P=0.5		
Never		13%	13%	9%	15%	2%
Almost never		14%	10%	9%	15%	0%
Sometimes		18%	14%	14%	14%	4%
Fairly often		5%	3%	4%	4%	0%
Very often		5%	3%	4%	4%	0%
Not applicable		0%	1%	0%	1%	0%
Animal rights activists		P=0.7		P=0.6		
Never		14%	14%	11%	15%	2%
Almost never		21%	12%	10%	21%	2%
Sometimes		11%	12%	14%	8%	2%
Fairly often		5%	3%	3%	4%	0%
Very often		3%	2%	1%	3%	1%
Not applicable		1%	1%	1%	1%	0%

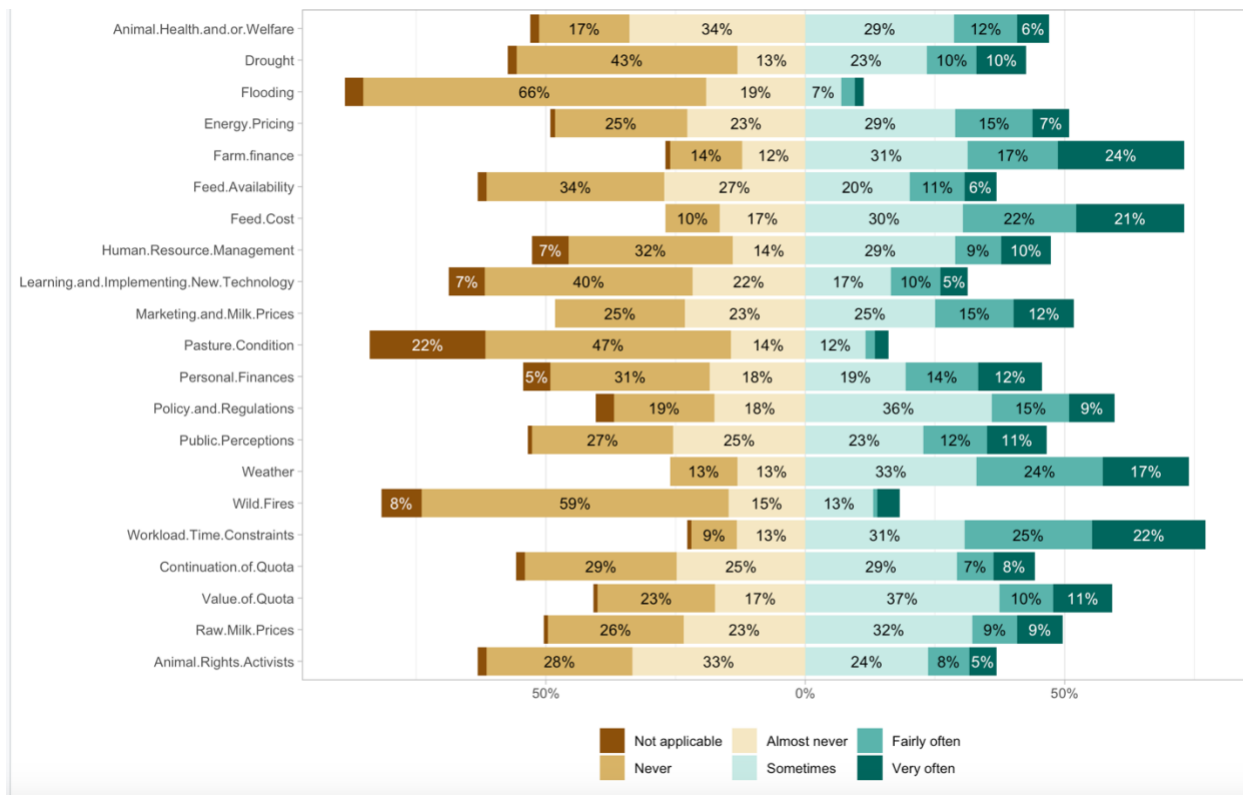


Figure 2.6 Proportion of specific stressors concerned reported

Table 2.15 Comparing Financial and transitional planning to mental health scores

Variable	Proportion	Stress	Anxiety	Depression	Resilience
Business plan		P=0.2	P=0.3	P=0.06	P=1
yes	31%	18.7(±5.9)	5.59(±5.08)	6.59(±3.92)	28.2(±6.1)
no	68%	16.8(±7.0)	4.69(±3.90)	4.71(±5.15)	28.2(±6.0)
Succession plan		P=0.4	P=1	P=0.5	P=0.6
yes	36%	18.2(±5.9)	4.86(±4.23)	4.86(±3.72)	28.5(±5.6)
no	64%	17.0(±7.2)	4.88(±4.33)	5.39(±4.72)	27.8(±6.3)
Annual risk assessment		P=0.4	P=0.8	P=0.7	P=0.2
yes	27%	18.2(±7.3)	5.03(±5.3)	5.43(±5.23)	29.2(±6.4)
no	73%	17.1(±6.6)	4.82(±3.87)	5.13(±4.09)	27.6(±5.9)

CHAPTER 3 | Not your average dairy farmer: Clustering dairy farmers of Western Canada and Ontario based on management practices and well-being.

Abstract

The landscape of dairy farming in Canada is highly diverse, encompassing a wide range of operational and management practices. This diversity poses a challenge in understanding the full spectrum of dairy farming systems, which may lead to incomplete representations and fewer effective interventions to enhance dairy farmers' well-being. The goal of this study was to holistically explore the link between dairy farmer well-being and farm management. We conducted a multiple factorial analysis (MFA) to categorize dairy farmers based on demographic characteristics, mental and physical health factors, farming responsibilities, work-life balance, social environment and support, animal housing and management, and dairy-related stressors. The analysis revealed four distinct clusters of farmers with varying management practices, and mental and physical health characteristics. We identified 66 statistically different variables across the clusters. The primary variables influencing the variation in the surveyed dairy farmers were financial concerns, public perception, policies and regulations, daily tasks, professional relationships (veterinarian and feed representative), and mental health outcomes. Notably, no physical health variables significantly differed among the clusters. The findings suggest that the well-being of dairy farmers is intricate and highly individualized. A uniform approach is unlikely to effectively address their diverse needs. Despite the differences among the clusters, most participants expressed a preference for allocating more time to enjoyable activities and reducing their workload to manage their stress. This indicates that the nature of dairy farming work and its associated responsibilities might naturally hinder farmers from achieving a healthy work-life balance. In summary, the challenges faced by farmers, such as managing stressors and financial pressures, underscore the importance of providing tailored support and resources to safeguard their well-being and overall quality of life.

3.1 Introduction

Systems thinking is a valuable tool for considering the bigger picture and understanding the complex interrelationships among economic, social, and environmental subsystems (Van Mai, 2010). Systems thinking is about investigating what elements and components could contribute to a possible outcome in a system. By applying this method of thinking to the dairy farm, we can consider numerous factors that represent the environment, the people, and the social factors (Finnigan, 2019). By learning to view dairy farms as a series of subsystems and by understanding the different parts within them, we can begin to better understand farmers' mental and physical well-being.

Dairy farming in Canada is quite diverse, with farms having different operational and management practices. This diversity makes it difficult to fully grasp the variability of the farming systems, resulting in incomplete representations of reality and less effective interventions to improve dairy farmers' well-being if one were to focus on "the average dairy farm". Currently, there is limited research on the overall health outcomes of Canadian dairy farmers and the primary stressors they encounter in their lives (Finnigan, 2019). Previous research on dairy farmer well-being has been focused on factors associated with farmer mental health, such as management practices, milk production and quality, and cow welfare (King et al., 2021). However, those researchers primarily used univariate and multivariate associations to explore mental well-being among dairy farmers in Canada, and, to our knowledge, no one has explored dairy farmer well-being holistically or created specific typologies based on farmer well-being and management practices.

In only a few studies have researchers explored the system thinking approach to answer complex questions in animal science. For example, the challenges faced by the beef value chain in Iran, were explained in by Alizadeh et al. (2020) who used a system thinking approach. They highlighted the use of system thinking to identify problems in the livestock value chain. Due to the unstructured nature of these problems, multiple factors, and the dynamic environment, a big picture of the system was necessary for planners and policymakers to make informed decisions. Moreover, Habanabakize et al. (2022) used a system thinking approach to create a typology of livestock that accurately reflects the realities of Senegalese farmers as they face the ramifications

of global climate change and its accompanying societal responses. However, the lack of understanding of the problems unique to each farmer's production system and the presumption of homogeneity have resulted in inefficient resource utilization and inappropriate intervention planning in the Senegalese dairy industry (Habanabakize et al., 2022). The typology confirmed a dynamic relationship between several variables, such as varying production goals and quantities, market access, animal breeds, and livestock management systems. Therefore, a comprehensive understanding of each farming system is required to enable decision-makers and relevant stakeholders to identify specific interventions required by farmers based on their individualized needs.

Efforts to improve the mental health crisis among dairy farmers have mainly focused on increasing access to mental health care, providing education and resources, and reducing stigma (Mendly-Zambo, 2023). However, these efforts may be sufficient when considering dairy farms as homogeneous, but insufficient when addressing the specific causes of poor health among farmers. Our study proposes a data-driven approach, where farm management practices, social and physical environment factors, and farmers' mental and physical health outcomes were collected through a survey and analyzed to propose a typology that helps characterize the current dairy production systems in Western Canada and Ontario, showing the differences, similarities, and constraints faced by dairy farmers.

3.2 Materials and Methods

3.2.1 Study Design

See section 2.2.1 for Study Design.

3.2.2 Statistical Analyses

A cluster analysis was carried out using R software to group dairy farmers based on their demographic characteristics, mental and physical health variables, farming responsibilities, work-life balance, social environment and support, animal housing and management, and specific

stressors. Missing observations on the continuation of quota (1.74%, n=2), equipment supplier technician (1.74%, n=2), pasture condition (2.61%, n=2), marketing and milk prices (2.61%, n=2), and cause of injury (2.61% n=2) were replaced by mean values for numerical variables and by zeros in the indicator matrix for the categorical variables using the PCAmixdata package (Chavent et al., 2022). Multiple factor analysis (MFA; Pagès, 2002), followed by hierarchical and k-means clustering methods, was used in this study. K-means clustering is a technique used in vector quantization. Its objective is to divide a set of n observations into k clusters, with each observation being assigned to the cluster whose mean (cluster center or centroid) is closest, effectively serving as a representative of that cluster (Hartigan & Wong, 1979). MFA is a multivariate data analysis method for summarizing and visualizing a complex data set in which individuals are described by several sets of variables. The MFA methodology is appropriate for analyzing survey data in which there is only one possible answer by respondent per question and questions are organized into groups based on the theme they cover (Abdi et al., 2013; Habanabakize et al., 2022). In this comprehensive analysis, multiple sets of variables are considered at the same time. However, in our study, our data included a mix of numerical and categorical variables. Therefore, we used an extension of the MFA, the MFAmixdata (part of the PCAmix package), which was developed to accommodate both types of variables (Chavent et al., 2022). The factor loads were extracted from the MFA and used to cluster farmers using the function HCPC (Hierarchical Clustering on Principal Components) from the R package FactoMineR (Lê et al, 2008), which was adapted to work on the MFA output from the R package PCAmixdata (Chavent et al.,2022).

First, hierarchical clustering using Ward's minimum variance method was conducted to establish the number of clusters defined based on inertia gain and medoids (Borcard et al. 2018). Inertia gain represents how well k-means clustered a dataset (Husson, 2017); this is calculated by measuring the distance between each data point and its centroid, squaring this distance, and summing these squares across one cluster. A good model is one with low inertia and a low number of clusters. The medoid is chosen to be the point that is most centrally located within a cluster in terms of dissimilarity to other points (Borcard et al., 2018). Both of these parameters were then used in the k-means clustering algorithm (Balijepally et al., 2011) using the Euclidean distance.

Chi-squared and ANOVA tests were then used to evaluate the differences between clusters in terms of categorical and continuous variables, respectively (Habanabakize et al., 2022). Significant

variables were ranked using a v-test which indicates the extent to which a variable within each cluster differs from the overall average, in which higher values are associated with greater extent and, greater relevance in explaining the cluster (Husson et al. 2017).

3.3 Results

3.3.1 General Farmer and Data Description

A total of 115 dairy farmers were included in this study. The average scores for mental health outcomes were: perceived stress = 17.3 ± 6.8 (mean \pm SD), anxiety = 4.91 ± 4.26 , depression = 5.21 ± 4.35 , and resilience = 28.1 ± 6.0 (Table 2.2) More details about the characteristics of the sample population can be found in Table 2.1.

Clusters represent farmers with similar practices, but being in the same cluster does not mean their practices are 100% identical, and being in different clusters does not mean farmers have no similarity in practices (Chavent et al., 2022; Habanabakize et al., 2022). All the results presented in the following results sections were computed using self-reported data by producers from the survey. A multiple-factor analysis identified 4 farmers clusters (Figure 3.1) among the surveyed dairy farmers. A total of 66 variables were found to be statistically different between clusters ($P < 0.05$). The v-test was used to rank the most relevant variables for describing each cluster. The top 10 variables with the greatest v-test value to describe each cluster were selected (Habanabakize et al., 2022). For numerical variables, we only used the v-test, and for categorical variables, we first identified the variables with the highest v-test value and then selected them based on whether at least half of the farmers in that cluster shared the same answer (e.g., out of 115 farms, 70% of farmers who mentioned getting enough sleep are in Cluster 1).

3.3.2 Cluster results

The main variables explaining variation in the dairy farmers surveyed were finances, public perception, policies and regulations, daily tasks, professional relationships (veterinarian and feed representative) and mental health outcomes. No physical health variables were significant in

cluster differentiation. Descriptions below relate to the majority of farmers in each cluster, as well as comparison of each cluster to the overall mean for all participants in the study.

3.3.2.1 Cluster 1

Compared to the overall average of study participants, the farmers in Cluster 1 ($n = 52$) have lower perceived stress scores (13.1 ± 6.0 vs. 17.3 ± 6.7 ; $P < 0.001$), lower depression scores (2.67 ± 2.24 vs. 5.21 ± 4.33 ; $P < 0.001$), and lower anxiety scores (2.65 ± 2.37 vs. 4.91 ± 4.24 ; $P < 0.001$) (Table 3.1). Additionally, most of the farmers in this cluster reported getting enough sleep (70%; $P < 0.001$) (Table 3.2). Notably, many of them expressed relatively little concern about personal finances (77%; $P < 0.001$), farm finances (94%; $P < 0.001$), milk prices (79%; $P < 0.001$), and human resources management (72%; $P < 0.001$) (Table 2). Furthermore, they had higher resilience scores compared to participants overall (30.6 ± 5.44 vs. 28.1 ± 6.0 ; $P < 0.001$) and most were never worried about public perceptions of dairy farming (74%, $P < 0.001$).

3.3.2.2 Cluster 2

Farmers in Cluster 2 ($n = 4$) were all responsible for managing the farm's finances and/or crops (100%; $P < 0.001$) (Table 3). They spent 0 to 20% of their time working with animals ($P < 0.001$) and 75% of these farmers are often concerned about drought ($P < 0.001$) (Table 3.3). Similarly, 75% of farmers in this cluster responded 'not applicable' regarding their relationship with the veterinarian and the feed representative ($P < 0.001$) (Table 3.3). They are secondary decision-makers (100%; $P < 0.001$) and they expressed very high dissatisfaction with professional support at work (100%; $P < 0.001$). Cluster 2 did not exhibit any quantitative variables that significantly differed from the overall average. This group was described using only 8 variables, as only 8 categorical variables had more than 50% of farmers sharing the same answer.

3.3.2.3 Cluster 3

Cluster 3 (n = 46) consists mainly of farmers who are responsible for animal care, cleaning the alleys and the barn, seasonal cropping, and milking the cows (78%) (Table 3.5). Most of them can maintain a healthy work-life balance (57%; $P < 0.001$). Farmers in Cluster 3 exhibit above-average levels of depression (6.85 ± 4.67 vs. 5.21 ± 4.33 ; $P < 0.001$) and perceived stress (PSS) (19.4 ± 4.8 vs. 17.3 ± 6.7 ; $P = 0.004$) (Table 3.4). They fall within the age range of 25-34 years (64%; $P < 0.001$). They feel somewhat valued by consumers (68%; $P < 0.001$) and all use compost as a secondary base (100%; $P < 0.001$). However, many of them are dissatisfied with professional support at work (87%; $P < 0.001$) and are fairly often worried about farm finances (71%; $P < 0.001$). Finally, most of them are rarely worried about animal rights activists (58%; $P < 0.001$).

3.3.2.4 Cluster 4

Cluster 4 (n = 14) stands out with an above-average anxiety score (10.1 ± 4.1) compared to the overall farmer population (4.91 ± 4.24 ; $P < 0.001$) (Table 3.6). The stress scores for this cluster are also notably higher (24.2 ± 5.0) compared to the overall average (17.3 ± 6.7 ; $P < 0.001$). Similarly, depression scores are considerably higher in this cluster (9.00 ± 3.81) compared to the overall average (5.21 ± 4.33 ; $P < 0.001$). Additionally, 67% of individuals in this cluster said they did not feel valued by consumers ($P < 0.001$) and 80% of farmers in this cluster are dissatisfied with their equipment supplier ($P < 0.001$) (Table 3.7). They all use a combination of organic and inorganic bedding (100%; $P < 0.001$). Furthermore, farmers in this cluster are very often worried about policy and regulation (50%; $P < 0.001$). They exhibit lower resilience than the overall average (23.8 ± 6.2 vs. 28.1 ± 6.0 ; $P = 0.005$) (Table 3.6). They all considered their relationship with the vet to be neutral (100%; $P < 0.001$). Half of the farmers in this cluster express concerns about animal rights activists ($P < 0.001$).

3.4 Discussion

3.4.1 Cluster 1: Farmers who navigate top farming stressors well.

In this group, the farmers represent the conventional image often associated with agricultural workers. Farmers in Cluster 1 show lower scores for mental health issues such as stress, anxiety, and depression, and they exhibit higher resilience compared to the overall farming population, indicating their ability to effectively handle and cope with stressors both in their work and personal lives. One of the standout strengths of farmers in Cluster 1 is their ability to effectively manage farming stressors, which is influenced by their lower levels of concern about stress. Importantly, they express less concern about milk prices, personal and farm finances, and public perception, which are commonly acknowledged as major stressors in farming (Finnigan, 2019). Their capacity to navigate financial difficulties is particularly remarkable, as it is widely recognized that financial pressures can significantly impact farmers' mental well-being (Finnigan, 2019; Jones-Bitton et al., 2020), potentially leading to stress, anxiety, and depression (Kato et al., 2022). Moreover, according to Finnigan (2019), the stress experienced by farmers stems from the disparity between the public perception of farming and the actual demands and challenges faced by those working on a farm. The farmers in Cluster 1 being less stressed about the financial aspect of dairy farming and public perception is likely one of the many reasons for their better mental health. Additionally, farmers in this group are largely unconcerned about managing human resources. In rural settings, farmers encounter a significant challenge in attracting and retaining workers due to a competitive labour market and the perception of undesirable job roles (Government of Canada, 2023). This is consistent with a study by Walker and Walker (1988), which highlighted the significant stress Canadian farmers face in securing and retaining reliable employees. Farmers in this specific group may have developed excellent relationships with their employees, perhaps due to a strong level of trust. Another potential factor could be the presence of reliable employees who work well with the farmers. This may have led to the development of strong working relationships and the establishment of robust professional support. Alternatively, the farmers may have delegated the responsibility of managing employees to someone else, resulting in limited direct interactions with the staff. Another possibility is that the individuals working on the farm may predominantly be family members, which may lead to a different dynamic in terms of management compared to hired employees.

The farmers in this cluster report getting sufficient daily sleep. Researchers emphasize that adequate sleep not only enhances learning and problem-solving skills but also contributes to improved attention, decision-making, and creativity (Deming et al., 1991; Sio et al., 2013).

Conversely, insufficient sleep has been associated with difficulties in decision-making, problem-solving, emotional regulation, and adaptation to change (Vandekerckhove & Wang, 2018). Furthermore, sleep deficiency is linked to mental health challenges such as depression, suicidal thoughts, and increased risk-taking behaviour. While insomnia has historically been viewed as a symptom of psychiatric disorders like anxiety and depression, recent findings underscore how sleep problems also contribute to the onset and exacerbation of various mental health issues, including suicidal thoughts (Feingold & Smiley, 2022). Studies on sleep deprivation highlight that those with existing mental health conditions are even more likely to struggle with chronic sleep problems. As farmers in this cluster reported getting enough sleep, they are probably less affected by the significant impacts that insufficient sleep can have on their mental well-being, or do not experience certain mental health conditions.

3.4.2 Cluster 2: Secondary decision makers who are responsible for farm finances and cropping.

Farmers in this category are secondary decision-makers who typically handle the farm's finances and crop management. As a result, their well-being is significantly affected by stress factors that are largely beyond their control (i.e., weather, market prices and fluctuations). A prevalent concern for farmers in this group is drought. Sturgeon and Morrissette (2010) found that financial strain and a lack of control over farming variables such as climate change and extreme weather events - such as droughts – were some of the main stressors of the industry (Abbas et al., 2022; Rocha et al., 2022). The pressures of the harvest season, compounded by adverse weather conditions and fluctuating market demands, can have a lasting and detrimental impact on these farmers' overall health (Parry et al., 2005). During these demanding and high-pressure time of the year, it is easy for farmers to overlook their well-being. The physical and mental strains associated with cropping can take a heavy toll on a farmer's health. Neglecting the signs of stress can lead to a range of issues such as fatigue, depression, anxiety, and other mental health conditions, an elevated risk of accidental injuries, impaired decision-making capabilities, and more (Pruthi, 2016). Decision-makers face a higher risk of experiencing poor mental well-being due to various challenges that come with running a business (Kato et al., 2022). Financial difficulties can lead to stress, anxiety,

and depression, while the need to ensure sustained financial management and managerial responsibilities further contributes to their mental well-being concerns (Kato et al., 2022). Their key stressors may differ from those experienced by farmers in other clusters, as they spend less than a quarter of their time working with animals. This suggests that they may be helping in animal care during peak animal-related workload periods and are less present at the barn during the field season. Because of this arrangement, they may have limited interactions with agricultural professionals (veterinarians, feed representatives or equipment suppliers). This is confirmed by the fact that farmers in this cluster did not report having a relationship with the veterinarian or the feed representative. In this cluster, farmers are very dissatisfied with the professional support they receive at work. This dissatisfaction could stem from the lack of control that secondary decision makers have over the farm, or if the choices made by the primary decision maker do not align with their own values. Additionally, the fact that they are responsible for quite stressful tasks such as managing finances and cropping already predisposes them to ongoing stress in their life, they can eventually begin to experience some feelings of money anxiety as a result. This anxiety can, in turn, have a negative impact on their everyday interactions with employees or family members working at the farm. Given the small sample size of farmers in this group, additional research is needed to comprehensively elucidate the variation and characteristics within this specific group.

3.4.3 Cluster 3: Young, multi-tasker dairy farmers who have concerns about farm finances but are still able to achieve a healthy work-life balance.

Farmers in Cluster 3 exhibit above-average levels of depression and perceived stress. They are hardworking young dairy farmers within the age range of 25 to 34 years who are responsible for a variety of tasks. Despite their demanding responsibilities, these dairy farmers are generally able to achieve a healthy work-life balance and manage their professional and personal lives. Additionally, most farmers in this group are fairly often worried about farm finance, which is consistent with their age and experiencing barriers to participate in farming. According to Kontogeorgos et al. (2017), the first barriers for young farmers are access to land and investments as well as access to the finances needed to build and grow a farm. It is very difficult to buy land,

machinery, and working tools in general. Dairy farmers face the additional challenge of acquiring quota through transfer or the new entrant program (Barichello, 1999; Doyon, 2011). In general, banks are hesitant to loan money to young people entering the field, mostly because there are a lot of risks associated with this type of investment and the returns are often far in time and not that attractive in quantity (Eistrup et al., 2019). This is mainly because the cost of production in the agricultural sector, especially at the beginning of a business, is very high. Additionally, the stigma surrounding debt can further exacerbate the mental health challenges faced by these individuals, leading to increased isolation and reluctance to seek help. In fact, individuals experiencing financial difficulty may resort to cutting back on essentials like heating and food, while also facing creditors. These financial challenges can substantially hinder recovery rates for common mental health conditions. According to a study in England, individuals with problematic debt are 4.2 times more likely to experience prolonged depression as compared to those without financial difficulty (Money and Mental Health Policy Institute, 2019).

Younger farmers may hold more progressive views of the dairy industry. They may be more confident about implementing sustainable practices including animal welfare. We found that they mostly also never worry about animal rights activists. However, studies that consider age as a variable for attitudes toward animal welfare are inconsistent. Some studies report, that older farmers had higher empathy scores (Balzani & Hanlon, 2020). Others did not find a significant relationship between age and welfare (Kılıç & Bozkurt, 2013; Pol et al., 2021).

The farmers within this particular group expressed their dissatisfaction with the lack of professional support in their workplace. This dissatisfaction can stem from various factors, including a negative work environment, ineffective management, absence of acknowledgment, and low wages. When employees are dissatisfied with their jobs, they may exhibit various behaviours. Some common indicators include a lack of enthusiasm and interest, and a feeling of disconnection from their colleagues or employees.

3.4.4 Cluster 4: Farmers who do not feel valued by consumers and worry the most about farming stressors.

Farmers in this cluster are of the highest immediate concern because of their high mental health scores and levels of concern about various stressors. In fact, farmers in Cluster 4 have the poorest

mental health scores of all four clusters and they also show the lowest resilience. These farmers are struggling with the stressors in their lives and the balance of perceived stressors and supports seemed unworkable. Furthermore, farmers in this cluster are not feeling valued by consumers. Anti-farming sentiments, especially regarding the raising of livestock, are becoming more widespread. These findings were consistent with Mendly-Zambo (2023), where farmers mentioned that public perception and pressure placed on them impacted their mental health. But also, they feel undervalued by society both financially and socially (Mendly-Zambo, 2023). While being recognized and valued by the public not only acknowledges their hard work but also validates the importance of their role in society (Hansen & Østerås, 2019). It is no secret that there is a disconnect between the rural and the urban population. This is due to a disparity between the public's perception of farming and its reality (Schuppli et al., 2023). Farmers feel that their occupation needs to be properly understood and valued by the public and the industry (Finnigan, 2019). The lack of understanding leads to distress, particularly when the integrity of farmers is questioned. Alternatively, not feeling appreciated or even being threatened or targeted by animal activists can be a great source of poor well-being, whether this takes place online or on the farm. Farmers in this cluster are very often worried about animal rights activists. In many countries, there is an increasing number of conflicts between those involved in animal production and animal rights activists. There have been multiple reported incidents where farmers have been targeted and victimized simply because they are involved in animal production (Ceccato et al., 2022; Finnigan, 2019). Additionally, policy and regulation are a frequent source of worry for farmers in this cluster. Farm Credit Canada has highlighted that regulations and paperwork are a significant source of stress for farmers. Changes in government can inadvertently add stress to farmers due to potential alterations in policies and regulations. As stated in Finnigan's (2019) report, the process of hiring temporary foreign workers has become increasingly intricate in terms of paperwork, administrative burden, and delays. The approval process for these applications can lead to significant stress for farmers who depend on this program (Finnigan, 2019). Moreover, the uncertainty surrounding access to these programs can also become a major stressor.

The majority of farmers were dissatisfied with their equipment supplier. The structure of dairy farming has evolved immensely in the past few years with regards to technology, size of operation, and the geographical location of farms. One of the consequences of these changes is that the business structure that supports dairy farms (e.g., equipment suppliers, and veterinarians) might

not react quickly enough to meet the changing demands of dairy farmers. Whether because of farm size or geographical location, farmers could be lacking the necessary farm inputs locally because the local business structure has not realized or has not been able to respond to their needs. Additionally, farmers could be stuck with a specific dealer because of financial commitment. On the other hand, farmers in this group were neutral about their relationship with their veterinarian. The reasons for this neutrality can be diverse ranging from veterinarian distribution to rural access. In fact, there is a worrying shortage of large animal veterinarians in Canada in the short term and in projections until 2031 according to the Canadian Occupational Projection System (COPS; 2022). It also extends in the US where the American Veterinary Medicine Association (AVMA) reported that 7% of veterinarians practice large animal medicine exclusively versus 60% for companion animals. The issue goes beyond initial perceptions, impacting farm profitability, animal welfare, and the overall sustainability of the dairy industry. This results in a shortage of expertise and availability of large animal veterinarians, particularly affecting dairy farmers. It is not just a matter of numbers, but also a geographical problem. Rural communities bear the brunt of this scarcity, often facing severe shortages. It is not uncommon for one large animal veterinarian to cover multiple regions, leading to delayed service and affecting emergency response times, as well as the health and productivity of herds (Weltzien, 2023). The dairy farmers in this group seem to feel indifferent about their relationship with their veterinarian. This could be due to feeling like they have no other choices and thus, they have to accept whatever services the veterinarian provides.

3.5 Support Resources and Recommendations

Cluster analysis is a tool that allows us to identify specific groups of farmers based on similarities in their practices, concerns and needs. By categorizing farmers into different clusters, we can better understand their unique requirements and provide more tailored support and resources to address their specific challenges. Participants were asked to choose the resources they believed would help reduce their stress. The stress management resources most favoured by participants were 'Scheduling more time for things I enjoy' (chosen by 64% of participants), 'Reducing workload' (49%), 'Retaining reliable employees' (34%), 'Attracting reliable employees' (33%), and 'Changes in production practices' (28%). Specifically, farmers in cluster 1 mentioned scheduling more time for things they enjoy (46%) and reducing their workload (27%) as the main resources needed. Farmers in cluster 2 also prioritized 'scheduling more time for things they enjoy' (100%), 'Attracting reliable employees' (100%), and 'Retaining reliable employees' (75%). In cluster 3, 83% believed that scheduling more time for enjoyable activities would decrease their stress level, while 78% saw reducing their workload as beneficial. When asked what resources would help reduce their stress, farmers in cluster 4 wanted scheduling more time for things they enjoy, better access to financial support resources, a reduced workload, and better emotional support from their families.

The resources selected by those in Cluster 1 suggest that farmers in this group work long hours to meet their workload demands. This raises the question of whether achieving a healthy work-life balance is feasible for dairy farmers. The resources cited by the other clusters do not correspond to their main characteristics describing them. According to the cluster results, Cluster 2 and 3 could use benefit from better access to financial and business support resources, such as marketing and human resource management advisors. Farmers in Cluster 3, in particular, could benefit from access to financial support resources, including capital and financial analysis tools, to help lower their stress about finances. Moreover, farmers in Cluster 2 might consider factors like drought risk when deciding what to produce and how to produce it. For example, due to drought, farmers might consider growing crops which require less capital investment and can be planted on fewer acres or shifted to other crops during a major drought. Moreover, implementing policies that enhance economic stability for farmers and farm workers is also important, as economic instability can significantly impact mental health. Cluster 4 desired better access to financial support resources,

reduced workload, and better emotional support from their family. However, their sources of poor mental well-being are multiple, and therefore, what they perceive and feel may not directly translate into their survey responses. The need to reduce workload is consistent with their concerns about policies and regulations when seeking employees, as current government constraints make it challenging to obtain much-needed workforce. Furthermore, they might feel similarly to Cluster 2 regarding the need for policies that enhance economic stability.

Notwithstanding the differences among the clusters, most participants favoured allocating more time to enjoyable activities and reducing their workload. This indicates that the nature of dairy farming work and its associated responsibilities might naturally impede farmers from achieving a healthy work-life balance.

3.6 Study Limitations

Self-reported data can be influenced by biases and errors from the individuals reporting it. There's a possibility that the producers may either overestimate or underestimate the information they provide. Additionally, our survey relied on voluntary participation, which means we can't guarantee the absence of recruitment biases. Also, when evaluating the connections between different farm clusters or variables, we need to test numerous statistical hypotheses, which increases the likelihood of identifying type 1 errors. It's also important to consider that the methods used to assess stress management resources might be biased or limited in fully capturing all the necessary resources for alleviating stress among farmers. Furthermore, the stress reduction resources identified may not effectively tackle the systemic issues within the agricultural industry that contribute to farmers' stress, such as financial instability and unpredictable market conditions. Lastly, the self-reported nature of the study could lead participants to either overestimate or underestimate the effectiveness of certain stress management resources.

3.7 Conclusion

The well-being of dairy farmers is complex and varies greatly from one individual to another. A one-size-fits-all approach will not be effective in addressing their diverse needs. Understanding the different types of dairy farmers is crucial in order to improve their well-being. In conclusion, the challenges faced by farmers, such as managing stress and financial pressures, emphasize the necessity of providing tailored support and resources to protect their well-being and overall quality of life.

Appendix 2

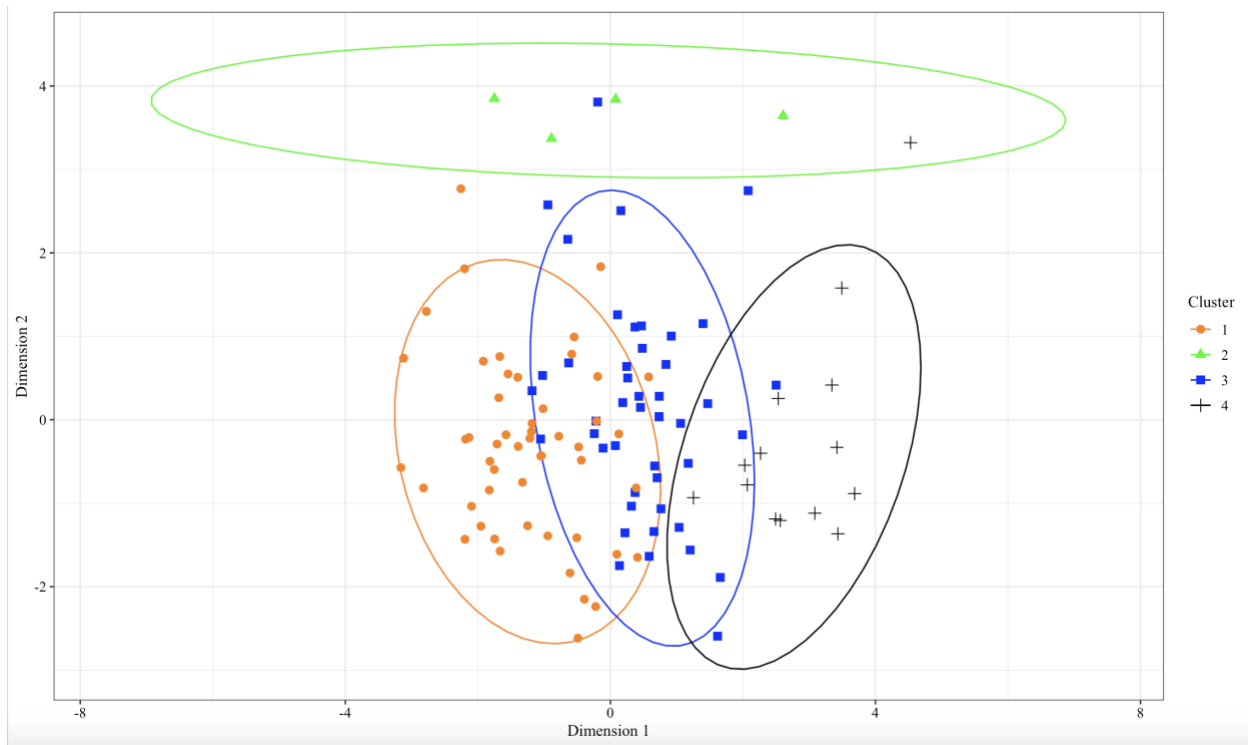


Figure 3.1 Plot depicting the 4 clusters of farmers.

Each point represents a farmer and each cluster is depicted by a different shape and colour.

Table 3.1 Top quantitative variables that best describe farmers from cluster 1

Variable	v-test	Cluster	Overall ²	P-value ³
PSS	-5.96	13.1 ± 6.02	17.3 ± 6.72	<0.001
PHQ-9	-5.59	2.66 ± 2.24	5.21 ± 4.33	<0.001
GAD-7	-5.10	2.65 ± 2.37	4.91 ± 4.23	<0.001
CD-RIC	3.92	30.6 ± 5.4	28.1 ± 6.0	<0.001

Table 3.2 Top categorical variables that best describe farmers from Cluster 1

Variable	v-test	Cla/Mod ¹ (%)	Overall ² (%)	P-value ³
Getting enough sleep: yes	4.84	70	43	<0.001
Personal finances: never worried	4.65	77	30	<0.001
Farm finance: never worried	4.33	94	14	<0.001
Milk prices: never worried	4.15	79	31	<0.001
HR management: never worried	4.01	72	27	<0.001
Public perceptions: never worried	3.86	74	27	<0.001

¹ Proportion of farmers in cluster 1 with that answer out of the overall number of farmers with that same answer

² Proportion of farmers with that answer out of the total number of farmers surveyed

³ Overall vs cluster ($\alpha < 0.05$)

Table 3.3 Top categorical variables that best describe farmers from Cluster 2

Variable	v-test	Cla/Mod ¹ (%)	Overall ² (%)	P-value ³
Tasks: cropping or finances	5.26	100	3.47	<0.001
Working with animals: 0-20%	4.28	75	7.82	<0.001
Drought: fairly often worried	3.21	75	7.82	<0.001
Veterinarian: no applicable	2.62	75	14	<0.001
Feed representative: no applicable	2.6	75	13	<0.001
Secondary decision maker	2.5	100	48	<0.001
Professional support at work: Very dissatisfied	2.11	100	1	<0.001

Table 3.4 Top quantitative variables that best describe farmers from Cluster 3

Variable	v-test	Cluster	Overall ²	P-value ³
PHQ-9	3.30	6.85 ± 4.66	5.21 ± 4.33	<0.001
PSS	2.82	19.5 ± 4.8	17.3 ± 6.7	0.004

Table 3.5 Top categorical variables that best describe farmers from Cluster 3

Variable	v-test	Cla/Mod ¹ %	Overall ² %	P-value ³
Tasks: Animal care, clean, crop, milk	4.08	78	20	<0.001
Work life balance: yes	3.80	57	52	<0.001
Age: 25 – 34 years	3.17	64	27	<0.001
Valued by consumers: slightly	3.13	68	22	<0.001
Secondary base: compost	2.93	100	5	<0.001
Professional support at work: dissatisfied	2.69	87	7	<0.001
Animal rights activists: almost never	2.69	58	33	<0.001
Farm finance: fairly often	2.68	71	16	<0.001

Table 3.6 Top quantitative variables that best describe farmers from Cluster 4

Variable	v-test	Cluster	Overall	P-value ³
GAD-7	4.90	10.1 ± 4.1	4.91 ± 4.23	<0.001
PSS	4.08	24.2 ± 5.0	17.3 ± 6.7	<0.001
PHQ-9	3.48	9.00 ± 5.21	5.21 ± 4.33	<0.001
CD-RIC	-2.80	23.9 ± 6.2	28.1 ± 6.0	0.005

Table 3.7 Top categorical variables that best describe farmers from Cluster 4.

Variable	v-test	Cla/Mod ¹ %	Overall ² %	P-value
Valued by consumers: not at all	4.74	67	10	<0.001
Equipment supplier: dissatisfied	3.39	80	4	<0.001
Bedding: organic + inorganic	3.18	100	2.61	<0.001
Policy and regulation: very often worried	3.02	50	8.70	<0.001
Vet: neutral	2.46	100	1.8	<0.001
Animal rights activists: very often worried	2.23	50	5.21	<0.001

CHAPTER 4 | General Discussion and Future Directions

4.1 Discussion of Research Findings

The objectives of my research were to benchmark farmer well-being across Western Canada and Ontario and understand interconnections between farm management and farmer well-being. More specifically, in this thesis, I: i) estimated the prevalence of mental and physical health outcomes and well-being (Chapter 2), ii) compared mental and physical health outcomes between different housing types, barn design, automation, and other management factors (Chapter 2), and iii) holistically explored the relationships between farmer well-being and farm management using systems thinking (Chapter 3).

A literature review (Chapter 1) was conducted to give context and rationale for this research. The literature review gave an overview of the dairy farming industry and the stressors associated with managing a farm. The first chapter established the broader aspect of the term "well-being" in the context of dairy farms. Ranging from the more medical aspects such as mental (stress, anxiety, depression and resilience) and physical health (injuries, sleep) but also factors which are more abstract such as work-life balance, positive social relationships, and active participation in enjoyable work and leisure activities. The methods used within the thesis were also introduced in Chapter 1, including univariate analysis and a multi-factor analysis. A cross-sectional, observational study was conducted from May 2023 to April 2024 in British Columbia, Alberta, Saskatchewan, Manitoba, and Ontario. The survey used validated psychological questionnaires to assess stress (Perceived Stress Scale; PSS), anxiety (Generalized Anxiety Disorder – 7; GAD-7), depression (Patient Health Questionnaire-9; PHQ-9), and resilience (Connor-Davidson Resilience Scale – 10 item; CD-RISC10) and questions on occupational injuries and farm management. Participants were also asked a series of questions about demographic characteristics, farming responsibilities, work-life balance, social environment and support, animal housing and management, and specific stressors.

In Chapter 2, I estimated the prevalence of mental health outcomes (stress, anxiety, depression, and resilience) and well-being among farmers in Western Canada and Ontario. I also explored different farm management and farming factors among dairy farmers in Western Canada and

Ontario, by comparing mental health and physical outcomes between different housing types, barn design, automation, and other management factors. The survey results were analyzed using means, standard deviation (SD), ranges, and proportions or prevalence for mental health outcomes. The mental health and physical health outcomes were presented in relation to key demographic factors such as age, province, gender, time managing the farm and decision-making roles. T-tests and ANOVA were used to compare means with general population averages and to test associations between mental health scores and survey variables. Chi-squared tests were used to compare physical health variables.

The study involving 115 farmers revealed that dairy farmers are more prone to experiencing heightened levels of stress, anxiety, and depression, coupled with lower resilience when compared to the general population. These findings are consistent with those of Jones-Bitton et al. (2020) and Thompson et al. (2022). Survey results uncovered that 16% screened positive for Generalized Anxiety Disorder (GAD), slightly higher than the reported scores for the Canadian population in spring 2023 (15.0%) and summer 2023 (14.0%). The prevalence of positive depressive disorder (PHQ-9 score >10) was lower among farmers (16%) compared to the overall Canadian population in 2023 (23%; MHRC, 2023). While Canadians tended to score in the most severe categories, more farmers scored in the mild and moderate categories of anxiety (GAD-7) and depression (PHQ-9). A similar observation was made by Thompson et al. (2022), who compared farmers' mental health scores to Canadians during COVID-19. Furthermore, farmers with over 10 years of experience in the industry displayed lower levels of anxiety compared to those with 1 to 4 years of experience, which aligns with Rudolphi et al. (2019) where younger farmers tended to be at an increased risk of anxiety. These findings depict a concerning picture especially for younger farmers as many individuals grappling with mental health issues like anxiety and depression often go unnoticed and progress into more severe conditions (Wang et al., 2005). Early detection of mental health disorders enables timely interventions before symptoms worsen into debilitating conditions. Rural and farming communities face a shortage of medical services, and mental health care providers may not always be accessible (Andrilla et al., 2018). Therefore, there should be a focus on early identification of mental health disorders.

The findings in Chapter 2 also revealed a significant gender disparity in the prevalence of anxiety and depression, with women exhibiting higher scores compared to men. This pattern has been

consistently documented in Canadian studies by Jones-Bitton et al. (2020), Thompson et al. (2022), and Walker & Walker (1987). The observed heightened vulnerability of women could be attributed to disparities in power dynamics and social status. The conflict between their roles in the farming sector and domestic responsibilities, along with the lack of family support, emerged as potential contributing factors (Berkowitz & Perkins, 1984). Furthermore, Berkowitz and Perkins (1985) and Millondaga (2018) indicated that depressive symptoms among women farmers were linked to experiences of perceived racial or ethnic discrimination and family conflict. Alston et al. (2022) also noted a notable correlation between increased work hours and heightened emotional distress among women, highlighting the tendency for farm women to prioritize their partner's health while neglecting their own well-being. The gender discrepancies elucidated in Chapter 2 underscore the urgency for targeted initiatives in farmer mental health research and intervention programs. It is imperative to delve deeper into the gender-specific nuances and to tailor mental health support services accordingly. Chapter 2 also revealed worrisome mental health outcomes for farmers in British Columbia, particularly related to anxiety and stress. The absence of detailed mental health information from different provinces presents a challenge when attempting to compare these results with regional studies. It is crucial to keep in mind that these differences may be affected by a variety of factors, including the timing of the study and ongoing underlying issues like climate change and inflation. Hence, it is imperative to consider the unique context of various regions, genders, and other factors that affect each farmer differently.

Our study also brings attention to important issues concerning the physical health of dairy farmers (Chapter 2). The majority of dairy producers I surveyed indicated that they have experienced work-related injuries or health issues on their farms, with older farmers reported more injuries. I also found an association between age and the occurrence of injuries, with older farmers reporting more injuries. These findings are consistent with several studies that have shown that older farmers with age-related health conditions, such as hearing impairments or vision loss, are at a higher risk of agricultural injuries (McCurdy and Carroll, 2000; Lewis et al., 1998). Additionally, older farmers often use older machinery that may not have modern safety features (Hansen, 1986). Furthermore, reduced reflexes may make older farmers more susceptible to injuries (Etherton et al., 1991). Men were more likely to report injuries related to machinery and the work environment. It is commonly recognized that men perform higher-risk tasks and behaviours (Udry, 1998). Numerous studies have indicated that the risk of farm-related injury is higher for men compared to women (Ferguson

et al., 1999; Hagel et al., 2004; McCurdy & Carroll, 2000; Pickett et al., 1999). My results also corroborate the findings of Dimich-Ward et al. (2004), who identified that a larger proportion of men sustained injuries while farming, irrespective of how the occurrence of injury was categorized, particularly when farm machinery was involved.

In Chapter 2, the importance of social relationships in bolstering the mental well-being of farmers was highlighted. It also underscored the value of family and having someone to confide in within the dairy farming community, contributing significantly to the resilience and mental health of farmers. Boyd et al. (2008) suggested that rural dwellers tend to lean more on their community for support during challenging times, in contrast to urban residents who often rely on their individual characteristics and values. Similarly, Caldwell and Boyd (2009) revealed that family support played a pivotal role in promoting psychological well-being among farmers. In my study, farmers who felt appreciated by the public displayed lower levels of anxiety and depression and greater resilience compared to those who did not feel appreciated. These findings align with Caldwell and Boyd's findings (2009), emphasizing how support from communities and groups is a strong indicator of psychological well-being, alleviating feelings of isolation and fostering a sense of belonging and support. Harandi et al. (2017) also demonstrated that feeling supported or valued significantly affects mental health outcomes, aiding individuals in managing their emotions and enhancing overall well-being. The overall impact of social relationships underscores the need for further exploration into the potential buffering effects of social support on stress and psychological well-being among farmers, given its positive impact.

The majority of the farmers I surveyed work every day of the week, which is in line with Statistics Canada's report, which indicates that most operators work over 40 hours per week on average. The impact on mental health is equally concerning, with a higher likelihood of depression and anxiety among those who consistently work long hours (Kivimäki et al., 2015). However, this study did not find significant evidence to support Kivimäki et al.'s (2015) findings, as there was no significant association between working days and mental health scores. It is crucial to highlight the importance of maintaining a healthy balance between work and personal life. In this study, farmers who managed to achieve a healthy work-life balance and took more time for rest, recreation, and things that bring them joy throughout an average week also reported lower stress levels and greater resilience. Therefore, the number of days worked per week could be a key factor

in helping individuals achieve this balance, contributing to improved mental health. While causation has not been proven, my research points to a link between balancing work and personal life and ensuring an adequate amount of sleep. Allotting enough time for oneself could enable farmers to structure their day effectively, leading to sufficient sleep.

Surprisingly, I found no association between mental health scores and farm size (number of cows), milking systems, housing types, and the use of technology. Even though King et al. (2021) suggested that farmers using automated milking systems might have better mental health, my study did not back up this idea. Similarly, in a Canadian study, Tse et al. (2018) revealed that dairy farmers using automated milking systems perceived their work to be less stressful and physically demanding, but my findings did not support this conclusion. The lack of significance may be due to farmers' proficiency in managing their operations in different production systems, or it may be influenced by post-purchase rationalization and choice-supportive bias. As my research did not include an assessment of the short-term or enduring effects of implementing new technological advancements or changes in the well-being of farmers, further investigation is recommended.

In Chapter 2, I delved into the intricate connections between achieving work-life balance, managing a farm, and the well-being of dairy farmers within the dairy industry. I explored the various ways in which farmer well-being can be linked to management practices. Findings from Chapter 2 suggest that farmers encountered both personal and farming-related stressors simultaneously, indicating a potential compounding of stressors. The lack of understanding of the unique challenges in each farmer's production system and the assumption of uniformity has led to inefficient or unsuitable intervention planning in the Canadian dairy industry (Mendly Zambo, 2023). Moving on to Chapter 3, a comprehensive analysis was conducted to propose a classification system that aids in characterizing the existing dairy production systems in Western Canada and Ontario. I suggested a data-driven approach, considering multiple sets of variables simultaneously.

A cluster analysis was carried out to group dairy farmers based on their demographic characteristics, mental and physical health variables, farming responsibilities, work-life balance, social environment and support, animal housing and management, and specific stressors. Significant variables were ranked based on their relevance in explaining the cluster (Husson et al. 2017). Four farmers clusters were identified, and 66 variables were found to be statistically

different between clusters. I identified several key variables that contributed to variations in the experiences of dairy farmers. These variables included financial factors, public perception, policies and regulations, daily tasks, as well as professional relationships with veterinarians and feed representatives. The impact of drought and mental health outcomes were also significant in explaining the variations observed among the surveyed dairy farmers. In Chapter 2, the primary sources of stress reported were associated with workload, feed prices, farm finances, and weather conditions. Moreover, the univariate analysis findings in Chapter 2 did not show any significant differences in mental health outcomes when compared with daily tasks, professional relationships, and concerns related to drought. These results indicate a potential gap in the traditional analysis methods used to study complex systems. To my knowledge, this type of analysis has not been used to investigate farmer well-being and make our results not comparable. Nevertheless, MFA seems to offer more specific descriptions and a broader perspective. However, the stressors found in Chapter 2 and 3 were consistent with previous studies, which also identified unpredictable weather, workload and economic pressures as the main sources of stress for farmers (Finnigan, 2019; Jones-Bitton et al., 2020). A study by Walker and Walker (1988) revealed that both men and women farmers in Canada were most stressed about their finances. Another study by Sturgeon and Morrisette (2010) also echoed our observations where financial strain and a lack of control over farming variables such as weather and farm culture were major stressors in farming.

Looking at farmer typologies created in Chapter 3, farmers in Cluster 1 exhibited better mental health, experience lower stress, and demonstrated higher resilience compared to the overall farming population. They reported fewer concerns about financial pressures and public perception, being able to effectively handle farming stressors, and to get enough sleep. Farmers in Cluster 2, often serving as secondary decision-makers, reported encountering significant challenges to their mental well-being due to financial strain and extreme weather events like drought. These farmers may have limited interactions with agricultural support personnel and may feel dissatisfied with the support they receive in their work. The financial and managerial responsibilities further exacerbate their concerns about their mental well-being. In Cluster 3, farmers aged 25-34 frequently contend with financial challenges, such as difficulty accessing land and obtaining loans. They expressed dissatisfaction with the lack of professional support in their workplaces. Farmers in Cluster 4 exhibit the highest levels of mental health concerns and they reported feeling undervalued by consumers. They are worried about animal rights activists and are stressed by

policies and regulations. Overall, the results of the MFA (Chapter 3) aligned with results from Chapter 2, where factors such as sleeping enough, being less concerned about industry-specific stressors, feeling more valued by consumers, and being older were associated with better mental health. My analyses in Chapter 2 revealed that farmers who did not feel valued by the public and are frequently worried about their farm finances and weather experienced higher levels of stress, anxiety, and depression compared to those who were not as concerned. Similar patterns were observed for policy and regulations, and animal rights activists.

Despite variations among the groups, most participants expressed that increasing the time spent on enjoyable activities and reducing their workload could help alleviate their stress. When looking at the cluster results, Clusters 2 and 3 seemed to require better access to financial and business support resources. Cluster 3, in particular, was identified as needing additional financial support resources, while farmers in Cluster 2 could benefit from improved access to resources supporting production for land use and sustainability. Those in Cluster 4 could benefit from more emotional support from their families and more consistent government policies and regulations. However, the selected supporting resources suggest that farmers work long hours to meet their workload demands and have less free time for other activities. These findings are troubling as they suggest that despite the current resources available to support their mental and physical health, dairy farmers are still struggling to find a balance between their work and personal lives. This raises the question of whether achieving a healthy work-life balance is even possible for dairy farmers. It implies that the structure of work and responsibilities in dairy farming might fundamentally hinder farmers from achieving this balance. Furthermore, the identified resources for stress reduction may not effectively address the systemic issues in the agricultural industry that contribute to farmers' stress, such as financial instability and unpredictable market conditions. Lastly, the self-reporting nature of the study may lead participants to overestimate or underestimate the effectiveness of certain stress management resources.

The findings from Chapter 3 indicate that current efforts to address the mental health crisis among dairy farmers may be insufficient. Farmers may be uninterested or unwilling to access currently available resources for a variety of reasons, and although there have been initiatives to enhance access to mental health care, provide education and resources, and reduce stigma, these efforts may not adequately tackle the specific causes of poor health among farmers, especially given the

diversity among dairy farms (Mendly-Zambo, 2023). A one-size-fits-all approach is unlikely to be effective due to the variation among dairy producers. The typologies developed in Chapter 3 offer a promising starting point for providing tailored support resources, and it is hoped that research on a larger scale will accurately depict the diversity of Canadian dairy farmers.

4.2 Study Strengths and Limitations

Surveys are effective for gathering large amounts of quantitative data, making them valuable for studying broader trends. When compared to qualitative methods, such as interviews, focus groups, and observations, surveys have the advantage of producing more standardized and consistent data that can be easily combined and analyzed. However, qualitative methods provide rich context that quantitative methods cannot capture. The survey results provided valuable insights into the overall health and well-being of Canadian dairy farmers and the main challenges they face. Additionally, by using a systems thinking approach to explore factors and interactions, we gained a more comprehensive understanding. By viewing dairy farms as a series of components of a system and understanding the different parts within them, we can better understand farmers' mental and physical well-being. To my knowledge, there has been no holistic quantitative exploration of dairy farmer well-being. Previous research has largely relied on statistical methods such as univariate and multivariate analysis. I believe that the extensive data collected in Chapter 2 and Chapter 3 will help identify opportunities for intervention by describing the interrelationships among economic, social, and environmental factors. Furthermore, we hope this will encourage others to consider unconventional analyses, such as multiple-factor analysis, for future research on farmer well-being.

Although surveys can be an effective and economical way to gather data in certain situations, it is important to be aware of their limitations and biases. One significant limitation of this study is the use of convenience sampling. The participants were not chosen randomly from a larger population, which could lead to sampling bias and restrict the applicability of the findings in Chapters 2 and 3 to other groups. Since participants were selected based on voluntary participation, they might share similar characteristics, potentially resulting in a lack of diversity in the sample. As a result, our

study's external validity might be compromised due to potential sampling bias and lack of diversity. Utilizing convenience sampling may also introduce unknown errors, as we might not be aware of how skewed or unrepresentative the sample is of the broader population. The survey should ideally employ a random sampling method in order to obtain a sample that is nationally representative and allows for linking participants over time. Another limitation is the lack of extensive studies on the subject that would allow us to compare our results. Most quantitative studies have broadly examined the well-being of farmers across commodity groups, and very few have focused on specific associations with farm management factors addressed in this research. Another limitation is that only univariate analysis were performed in Chapter 2, because we may be prone to offer variables in a multivariate analysis which we believe would support my hypotheses, perhaps contributing to researcher bias.

Some additional questions surfaced that I had wished I had included in the survey. For instance, while we did ask farmers about their roles as primary or secondary/co-decision makers on the farm, we did not ask whether they had ownership of the farm. Having more “skin in the game” could drastically impact the way a person experiences occupational stressors.

4.3 Next Steps for Research

4.3.1 Impacts of changes on farmer well-being

Our research did not include an assessment of the enduring effects of implementing new technological advancements or changes in the well-being of farmers. For example, farmers installing automated milking system (AMS), automated feeders, or automated bedding systems may encounter stress associated with adapting to new technology, modifying their farming techniques, and managing potential decreases in milk production in the first weeks. While AMS are increasingly prevalent, there is limited documentation regarding the overall impact of AMS on farms and the specific challenges and benefits faced by producers during the transition to this technology. Developing a more comprehensive approach would entail conducting a long-term investigation into the mental well-being of farmers to ascertain whether stress factors remain constant over time or fluctuate from year to year. It would be beneficial to employ mixed methods similar to Hagen et al. (2021) involving interviews with farmers and agricultural experts to gather

first-hand experiences and insights into the challenges and advantages encountered during the transition to new technology or housing. Subsequently, the long-term impact of these changes on the mental well-being of farmers could be evaluated through multiple surveys collected over an extended period, comparing stress levels and challenges to determine the consistency or variation.

4.3.2 Investigate Effectiveness of Supporting Resources

It is crucial to thoroughly examine the long-term effects of various resources available to promote mental well-being to determine their efficacy. This entails closely scrutinizing the ways in which these resources aid in sustaining and enhancing mental health over an extended period through controlled studies of various interventions. To achieve this, it is imperative to assess the methodologies and findings of previous studies to gain a thorough understanding of the impact of these proposed supportive resources. Furthermore, gathering and analyzing both quantitative and qualitative data is essential to present a comprehensive body of evidence that substantiates the evaluation. Further research could benefit from combining a multiple factorial analysis with qualitative results.

4.4 Conclusions

As a dairy farmer, one must endure physical labour, long hours, and a high level of responsibility for animals. The demanding nature of farm work and the constant presence required can impact the health and well-being of dairy farmers. This study has shed light on the concerning state of mental and physical well-being of dairy farmers. Farmers face personal and farming-related stressors simultaneously, potentially compounding their stress. A comprehensive approach reveals the diversity of farmers and the possible inadequacy of current support resources. The findings of this review support the idea that farmers' mental health challenges result from a complex interplay of social, environmental, and economic factors.

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Appendix 3

A. Questions about you and your role on the farm

Please select your age group:

- 17 or younger (excluded)
- 18-29
- 30-39
- 40-49
- 50-59
- 65 or older

Please select the province your farm is located:

- Alberta
- British Columbia
- Manitoba
- Ontario
- Saskatchewan
- Other (excluded)

With what gender do you identify? _____

How involved are you in the decision-making process on your farm?

- I am a primary decision maker
- I am a secondary decision maker or co-decision maker
- I am not actively involved in making decisions (excluded)

How long have you owned/managed the farm as a primary or secondary decision maker?

- Less than a year
- 1-5 years
- 5-10 years
- 10 or more years

On your operation, roughly what proportion of your time do you spend working directly with animals?

- 0-20%
- 21-40%
- 41-60%
- 61-80%
- 81-100%

On your operation, roughly what portion of your time is spent working alone?

- 0-20%
- 21-40%
- 41-60%
- 61-80%
- 81-100%

From the list below, please select all farm work you perform on a regular basis:

- Calf management
- Cleaning and bedding stalls/pack
- Cleaning milking equipment
- Cropping (seasonally)
- Feeding cows and heifers
- Finances
- Health checks and treatments
- Milking cows (including bringing to parlour/robot)
- Reproduction and breeding
- Other _____

Does your workload allow you to achieve a healthy work-life balance?

- Yes
- Sometimes
- No

During an average week, how often are you able to take time for recreation or rest or anything that brings you joy? (i.e. sports, playing games with family, walking the dog, spending time with calves, watching TV, etc.)

- Less than once per week
- Once per week
- A few times per week
- Nearly everyday
- Everyday

On average, how many days do you work per week? (This includes time spent physically at work, or any work you may do from home)?

- 1
- 2
- 3
- 4
- 5
- 6
- 7

How much vacation time do you take per year (not including your regular days off)? (This time does not need to be consecutive)

- None
- 1-2 days
- 3-6 days
- One week off
- Two weeks off
- Three weeks off
- Other: _____

B. Social environment & support on the farm

The next set of questions asks about your social environment at work because we would like to learn about your work environment and support network.

How many total workers (full time and part time, not including yourself) do you employ on your farm? (Please include family members who work on your farm).

Please select the people who work on your farm as full-time or part-time workers: (Select all that apply)

- Spouse
- Parent(s)
- Child(ren)
- Sibling(s)
- Another family member(s)
- Hired employee(s)
- Other (please specify): _____

Are you satisfied with the personal/social support you receive at home?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very Satisfied

Do you have someone you feel comfortable talking to at work about any concerns (personal, work-related)?

- Yes
- No

Are you satisfied with the personal/social support you receive at work (this may include family members who you work with)?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very Satisfied

Are you satisfied with the professional support you receive at work(this may include family members who you work with)?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very Satisfied

Which people outside of your operation (i.e., non-employees) do you have a working relationship with? (Select all that apply)

- Equipment supplier/technician
- Financial advisor or accountant
- Livestock breeding contractor/technician
- Livestock extension / livestock specialist
- Neighbour/other farmers
- Nutritionist/Feed Representative (whoever you work with more)
- Veterinarian
- Other (Please Specify) _____

Are you satisfied with the professional support you receive from your veterinarian?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very Satisfied
- Not applicable

Are you satisfied with the professional support you receive from your nutritionist/feed representative?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very Satisfied
- Not applicable

Are you satisfied with the professional support you receive from your equipment supplier/technician?

- Very dissatisfied
- Dissatisfied
- Neutral
- Satisfied
- Very Satisfied
- Not applicable

As a farmer, how valued/appreciated do you feel by the dairy industry? (Dairy boards, DFC, etc.)

- Not at all valued
- Slightly valued
- Somewhat valued
- Very valued
- Extremely valued

As a farmer, how valued do you feel by consumers and the general public?

- Not at all valued
- Slightly valued
- Somewhat valued
- Very valued
- Extremely valued

C. Record keeping and planning for the future

Are your financial records up to date (as of April 1, 2023)?

- Yes
- No

What format do you use to keep your financial records?

- Hand-written notes
- Formatted hand-written records or handwritten spreadsheet
- Basic online spreadsheet
- Specialized software
- A combination of handwritten and online
- Other (please specify) _____

Do you have a written business plan?

- Yes
- No

Was your business plan created with professional assistance?

- Yes
- No
- Not applicable

Do you have a written farm transition or succession plan (to transfer ownership and control of farming assets to the next generation to continue the business)?

- Yes
- No

Was your transition plan/succession plan created with professional assistance?

- Yes

- No
- Not applicable

Do you conduct risk assessments annually and have a written risk management/contingency plan(s)?

- Yes
- No

Are you planning any changes to your operation in the upcoming year? (ex. renovations, installations)

- Yes (Please specify) _____
- No

D. Housing & Management of Dairy Animals

Which breed of cattle do you have? _____

How many lactating cows do you typically have? _____

Which best describes the barn in which you currently house lactating cows?

- New construction (within the last 5 years)
- Retrofit
- Original
- Other

Do you have any of the following technologies on your farm? (Select all that apply)

- Activity monitors (collar, ear tag)
- Automated bedding delivery system
- Automated calf feeder
- Automated feed mixing and/or delivery system
- Automated footbath
- Automated manure scraper/robot
- Automated milking system
- Milk quality monitor (i.e., SCC, OCC, Herd Navigator, etc.)
- Rumination monitors (collar, ear tag)
- Other (please specify) _____

In the last 2 years, have you installed/incorporated any of the following technologies on-farm? (Select all that apply)

- Automated milking system
- Automated calf feeder
- Automated feed mixing and/or delivery system
- Automated bedding delivery system
- Automated manure scraper/robot

- Automated footbath
- Rumination monitors (collar, ear tag)
- Activity monitors (collar, ear tag)
- Milk quality monitor (i.e., SCC, OCC, Herd Navigator, etc.)
- Other (please specify) _____

On your farm, where do you house the majority of your lactating cows?

- Free stall
- Tie stall
- Bedded pack
- Other (please describe)
- Combination (please describe)

Which stall base do you have for lactating cows? (Select all that apply)

- Concrete
- Mattresses
- Pasture mat
- Rubber mat
- Sand
- Water beds
- Other (please specify) _____

Which type of bedding material is used for lactating cows? (Select all that apply)

- Cardboard
- Compost
- Peat moss
- Recycle paper
- Sand
- Sawdust or wood shavings
- Straw
- Wood chips
- Other (please specify) _____

How often is new bedding is added?

- Once a month
- Once a week
- Once a day
- 2-3 times per day
- 4 to 6 times per day
- Not applicable

Who normally performs hoof trimming?

- Professional hoof trimmer
- Veterinarian
- Producer or employees
- Other, please specify: _____
- Not applicable

How frequently do you run a footbath for your lactating cows?

- Less than once a month
- Once a month
- Twice a month
- Three times a month
- Four times a month or more times a month
- Not applicable

How many times per day is fresh feed is delivered to lactating cows?

- Once
- Twice
- Three times
- Four or more time

Which type of milk do you produce?

- Conventional milk
- Organic milk
- A2 milk
- DHA milk

Do you participate in routine milk testing (Lactanet, formerly DHI)?

- Yes
- No

If you have an automated milking system, what cow traffic system do you use?

- Milk First Feed First Free Flow

E. Animal health questions:

Over the last 12 months, what was your approximate calf mortality rate for calves under 3 months old? _____

**Over the last 12 months, how many cases of mastitis did you have on your farm?
(Please include recurring cases for a single cow and count them as multiple cases.)**

F. Occupational health & well-being

**Have you experienced any of the following injuries or health problems while farming?
(Select all that apply)**

- Broken bone/Fracture
- Burns
- Chronic use injuries/joint pain
- Contusion Head injury/concussion

- Dislocation/sprains
- Laceration (requiring stiches)
- Major bruises
- Partial or complete loss of eyesight
- Partial or complete loss of hearing
- Respiratory disease
- Tendon lesion/injury
- Amputation
- Other _____

What was the cause of the injury? (Select all that apply)

- Machinery or equipment (i.e., tractor, truck, farm machines, etc.)
- Work Environment (i.e., slippery surfaces, unlevelled terrain, splash with chemicals, confined spaces, etc.)
- Animals (i.e., kick, bites, headbutts, stepped on, etc.)
- Other _____

On average, how many hours do you sleep?

- Less than 5
- 5-6
- 7-8
- 9-10
- More than 10

Do you feel like you are getting enough sleep per night?

- Yes
- No

The following section involves questions to ask you about your feelings and thoughts during the last month to assess your stress level.

In each case, you will be asked to indicate by selecting how often you felt or thought a certain way.

In the last month, how often have you been upset because of something that happened unexpectedly?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you felt that you were unable to control the important things in your life?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you felt nervous and “stressed”?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you felt confident about your ability to handle your personal problems?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you felt that things were going your way?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you found that you could not cope with all the things that you had to do?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you been able to control irritations in your life?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you felt that you were on top of things?

- Never

- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you been angered because of things that were outside of your control?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

In the last month, how often have you felt confident in your ability to handle your business and operation problems?

- Never
- Almost never
- Sometimes
- Fairly often
- Very often

The following section involved questions used to assess your resilience.

Please rate how you have felt over the past month.

I am able to adapt to change:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

I can deal with whatever comes:

- Not true at all
- Rarely true
- Sometimes true

- Often true
- True nearly all of the time

I try to see the humorous side of problems:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

Coping with stress can strengthen me:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

I tend to bounce back after illness or hardship:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

I can achieve goals despite obstacles:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

I can stay focused under pressure:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

I am not easily discouraged by failure:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

I think of myself as a strong person:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

I can handle unpleasant feelings:

- Not true at all
- Rarely true
- Sometimes true
- Often true
- True nearly all of the time

The following section involves questions used to assess your mental health.

Don't take too long over your replies: your immediate reaction to each item will probably be more accurate than a long thought-out response.

Over the last 2 weeks, how often have you been bothered by any of the following problems?

Little interest or pleasure in doing things

- Not at all
- Several days
- More than half of the days
- Nearly every day

Feeling down, depressed, or hopeless

- Not at all
- Several days
- More than half of the days
- Nearly every day

Trouble falling or staying asleep, or sleeping too much

- Not at all
- Several days
- More than half of the days
- Nearly every day

Feeling tired or having little energy

- Not at all
- Several days
- More than half of the days
- Nearly every day

Poor appetite or overeating

- Not at all
- Several days
- More than half of the days
- Nearly every day

Feeling bad about yourself – or that you are a failure or have let yourself or your family down

- Not at all
- Several days
- More than half of the days
- Nearly every day

Trouble concentrating on things, such as reading the newspaper or watching television

- Not at all
- Several days
- More than half of the days
- Nearly every day

Moving or speaking so slowly that other people could have noticed? Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual.

- Not at all
- Several days
- More than half of the days
- Nearly every day

Thoughts that you would be better off dead or of hurting yourself in some way

- Not at all
- Several days
- More than half of the days
- Nearly every day

Over the last two weeks, how often have you been bothered by any of the following problems?

Feeling nervous, anxious or on edge

- Not at all
- Several days
- More than half of the days
- Nearly every day

Not being able to stop or control worrying

- Not at all
- Several days

- More than half of the days
- Nearly every day

Worrying too much about different things

- Not at all
- Several days
- More than half of the days
- Nearly every day

Trouble relaxing

- Not at all
- Several days
- More than half of the days
- Nearly every day

Being so restless it is hard to sit still

- Not at all
- Several days
- More than half of the days
- Nearly every day

Becoming easily annoyed or irritable

- Not at all
- Several days
- More than half of the days
- Nearly every day

Feeling afraid as if something awful might happen

- Not at all
- Several days
- More than half of the days
- Nearly every day

What resources would help reduce your stress? (Select all that apply)

- Reduced workload
- Finding more time for the things I enjoy (including time family, self-care etc.)
- Attracting reliable employees
- Retaining reliable employees
- Better emotional support from my family
- Better access to preventative stress management and mental health resources
- Better access to mental health treatment services (counsellor, therapist, doctors, etc.)
- Better access to production support resources (equipment, technology, land, etc.)
- Better access to financial support resources (including capital and financial analysis tools)

- Better access to business support resources (including marketing, human resource management advisors, etc.)
- Better understanding of my business options and opportunities (including financial, marketing, human resource management, farm transition, technology, etc.)
- A change in my production practices (ex. timing, equipment, buildings, technology, etc.)
- A change in my business practices (ex. planning, record-keeping, human resource management, marketing, financial analysis, etc.)
- Other: (please specify) _____

The following table seeks to determine specific stressors on your operation.

In the past month, how often have you felt stressed or concerned by the following on a scale of 0 to 5 (0 = Never; 4 = Always)? Please check the box that describes your level of concern for each.

	Never 0	Rarely 1	Sometimes 2	Very often 3	Always 4	Not Applicable
Animal health						
Animal rights activists						
Continuation of quota						
Drought						
Energy pricing						
Feed availability						
Feed costs						
Finances (personal and farm)						
Flooding						
Government policy and industry regulations						
Human resource management						
Installing new farm machinery						

Public perception						
Raw milk prices						
Transitioning the farm to the next generation						
Value of quota						
Weather						
Wildfires						
Workload/time constraints						
Other (please specify)						