Work Organization Model Applied on Smallholder Dairy Farms in Brazil

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Abstract: This research identified difficulties faced by dairy farmers in family farming, describing this diagnosis through ergonomic demand items (EDIs). The objective was to elaborate an organization model of work related to dairy farming (WRDF). As a methodology, a descriptive exploratory study was carried out in 14 family dairy farms that were visited and had their activities monitored. As main results, 11 EDIs were identified. The ones grouped in the infrastructure factor showed the highest resolution priority. The WRDF model was composed of three categories: management, public policies management and infrastructure, which were further subdivided into technical and social aspects. From this perspective, it is believed that the implementation of the model can bring organizational improvement, once adjustments are made in the procedures and working conditions. This study sheds light on the conditions that need to be resolved with higher priority so that the farmers will remain in the dairy business.

Key words: Milk production, Brazil, dairy farming, ergonomics, work environment.

1. Introduction

Milk production is a globally relevant activity, encompassing more than 150 million rural properties and with approximately 750 out of 895 million workers directly or indirectly involved in this production [1]. Another important characteristic of this production branch is that approximately three-quarters of dairy farms have a predominant family labor force [2].

Also, in Brazil, milk production has this characteristic, and several studies highlight the importance of dairy farming for the sustainability of agricultural properties, self-consumption and, mainly, the generation of family income [1, 3].

Domestic milk production increased by around 75% in Brazil between 1990 and 2006, with half of this production coming from family farming [4]. This growth was repeated with an average annual rate of

more than 3.1% between 2011 and 2014, reaching a production of 35.1 billion liters [5]. However, in 2015, there was a decline of around 2.8%, resulting in a production of only 24.0 billion liters [6]. This decline remained in the first quarters of 2016 with a 6.7% production drop, mainly in Southern Brazil.

Dairy farming, in addition to family labor and the repercussions of economic crises that plague the country, has other characteristics [7]: (1) work is usually developed in inappropriate situations and this creates potential health risks for the worker. In addition, there are few equipment and technologies, which generate a lot of physical overload [8]; (2) there is no distinction between the domestic environment and the work environment. Dairy farmers reside at their workplace, leading to a domiciliation of the risk that ends up affecting the whole family; (3) milking is carried out daily, usually twice a day, without weekly breaks [9], leading to long working hours with uncontrollable environmental conditions; (4) workers generally have low income and education [10]. These situations tend to aggravate occupational hazards and

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negatively impact the producers' adherence to dairy farming. Thus, this situation influences the economic viability of the properties and the decision to remain in this branch of activity.

Therefore, in the context of dairy farming, ergonomics has stood out as extremely useful. It can contribute to the improvement of work organization, as well as to the protection of the dairy farmers' health [9, 11, 12]. However, few studies have examined how farmers organize their work to meet market demands [1]. From this lacuna, the present study sought to present contributions on the way this work was organized in order to identify the points that can be modified to make it more efficient. In view of these assumptions, this study aimed to identify the ergonomic demand items (EDIs) to subsequently elaborate an organization model of work related to dairy farming (WRDF) as a way to improve their working conditions.

2. Materials and Methods

2.1 Study Area and Sampling

This research was carried out in 14 dairy farms with family labor, whose main production was milk of bovine origin. These properties are located in two municipalities (Araruna and Campo Mourão), in the mid-western center of the state of Paraná, Brazil. At these farms, 27 dairy farmers (i.e., milk parlor workers), all members of their respective families, worked with milk production. All were interviewed and had subsequently their work activities monitored. Based on the identified labor force of these properties, they were classified into three forms: (1) family association—when they involved other family members besides the farmer and his wife; (2) couple—when formed only by the husband and his wife; (3) individual—only one person carried out the work.

This research was submitted and approved by the Ethics in Research Involving Human Beings Committee, under CAEE number: 21513713.5.0000.0121.

2.2 Data Collection Techniques

Data collection was performed in three stages:

(1) In the first stage, the initial visits to the properties were carried out and all the family members who worked with the milk production (handling and milking) were interviewed. In this structured interview, data on the dairy farmers (age, gender, schooling, time in the occupation and age at which they began to work as farmers) and on characteristics of the properties (adopted production system, size of the property and the livestock, number of milked animals, production volume, number of milkings per day) were collected.

(2) In the second stage, random on-site visits were carried out for the initial understanding of the existing problems, work follow-up and diagnosis of the situation. This was done through ergonomic work analysis (EWA) to identify the EDIs, according to the technique proposed by Guimarães [13].

(3) In the third stage, the WRDF model was elaborated, demonstrating the hierarchy of the problems identified from the EDIs.

2.3 Data Analysis

From the collected data, the descriptive analysis of the sample with position and dispersion measurements was exhibited. The EDIs were prioritized in the order that each item was mentioned. Thus, for each item mentioned in position (p), the weight $1/p$ is assigned. For example, the first factor mentioned was given weight $1/1 = 1$, the second one $1/2 = 0.5$, the third $1/3 = 0.33$, and so on, respectively. With the obtained results, the weights relative to each mentioned item were summed, creating an importance ranking of the items. These items were grouped into factors that were later used to construct the WRDF model.

3. Results

3.1 Descriptive Analysis of the Surveyed Dairy Farmers

Of the 27 dairy farmers, the majorities are male,

comprising 66.7% (18) of the sample, and 33.3% (9) are of the female gender. The average age of the interviewees was 44 years old (the youngest was 19 years old and the oldest 72).

Regarding working time in the milk production sector, the average among the dairy farmers was 15 years. The average age they started working was 20 years old (minimum of eight years, maximum of 46, $SD \pm 11.85$ years).

In regard to their educational level, the majority of the respondents had a low education level, 44.45% of which had only incomplete elementary education.

3.2 Descriptive Analysis of the Family Dairy Farms

Income from milk production represented 90% of the total income in seven farms. Regarding the size of the dairy farms, the average was 20.51 ha. With respect to the size of the herd's pasture area, the average among the surveyed properties was 7.82 ha with a minimum size of 1.20 ha, maximum of 26.6 ha, $SD \pm 6.37$ ha. The main characteristics of the dairy farms participating in the research were shown in Table 1.

The average livestock on the farms was 38 animals (ranging from 15 animals to 78 animals). The number of milked cows varied according to the time of year and the gestations of the animals. At the time of data collection, the mean number of milked cows was 16 animals (ranging from 8 animals to 27 animals). The daily milk production reached an average of 229.57 L, with a large oscillation in the milk volume between the properties (between 100 L/d and 600 L/d).

Regarding the milking system, all the farms used mechanical milking, which was differentiated into two systems: (1) mechanical milking with bucket on ground-level, adopted in 12 dairy farms. Four of these

farms have a transporter to assist in the milk's passage to the cooling tank. Only one property has a milking parlor with differentiated height for the milking machine (operator pit); (2) only two dairy farms have the automated mechanical milking system connected to milk ducts with a herringbone milking parlor with an operator pit (Fig. 1).

3.3 EDIs

Dairy farming is an activity influenced by internal and external factors and is pointed out by the surveyed dairy farmers as a very worrying activity due to the difficulties they face. These conditions make it difficult to stay in this activity. The difficulties identified in the dairy farms are treated in this study as EDIs, as shown in Table 2.

According to the surveyed farmers, the main EDIs (Table 2) are:

(1) Hygiene and difficulties accessing the milking place.

The accumulation of mud and animal waste near the milking place is one of the main problems identified in the surveyed dairy farms. This is due to the absence of water drainage (rainwater runoff and sanitation facilities). Two factors that the dairy farmers consider worrying are: the increase in the physical effort they are required to endure during the cleaning of the place and the animals' predisposition to disease and stress.

(2) Herd's handling.

According to the farmers, the difficulties are: high daily working hours and high costs to keep the herd in good condition (food, vaccines, medicines, tests, etc.). In this item, the difficulties involve two factors: feeding the herd and the technical milk production system. The dairy farmers faced serious difficulties in properly feeding the animals. In times of drought or

Table 1 Characteristics of the 14 surveyed farms.

Municipality	Number of farms	Size of the farms (ha)	Pasture area (ha)	Size of the herd	Milked animals	Production (L/d)
		Mean/standard deviation				
Campo Mourão	7	28.00 $\pm$ 19.87	10.19 $\pm$ 8.30	41.57 $\pm$ 23.67	16.43 $\pm$ 6.00	218.57 $\pm$ 176.58
Araruna	7	13.03 $\pm$ 4.64	5.46 $\pm$ 2.48	34.43 $\pm$ 14.06	14.00 $\pm$ 4.28	152.86 $\pm$ 39.04
Total (average/standard deviation)		20.51 $\pm$ 15.89	7.82 $\pm$ 6.37	38.00 $\pm$ 19.07	15.86 $\pm$ 4.82	229.57 $\pm$ 159.26

Fig. 1 Distribution of the milking systems of the surveyed properties.

Table 2 EDIs mentioned by the surveyed dairy farmers.

EDI	Number of answers	Order of mentioning the item	Weight	Sum
Hygiene and difficulties accessing the milking place	13	1	1.000	13.000
Herd's handling	13	2	0.500	6.500
Milking parlor (facilities)	12	3	0.333	3.996
Incentives by governmental agencies	10	4	0.250	2.500
Working hours	7	5	0.200	1.400
Road (access to the farms)	6	6	0.166	0.996
Price of the milk	5	7	0.143	0.715
Technical assistance (production support)	5	8	0.125	0.625
Handling loads	5	9	0.111	0.555
Livestock health management	5	10	0.100	0.500
Planning	2	11	0.090	0.180

rain, there was food shortage, since the harvest did not meet the storage demand in these periods. To meet this shortage, it is necessary to buy silage, burdening the activity (which has a very small profit margin per produced liter). The land area for planting and animals' pasture, the inadequate financial resources and the inadequate machinery and equipment influence the poor quality of the food. As for the technical milk production system, the greatest deficiency was related to reproductive aspects, e.g., artificial insemination and specialized herding (appropriate selection of animals). In this case, the complaints were mainly related to the genetic potential, persistent lactation and reproductive efficiency. The low schooling level of the dairy farmers negatively impacted the activity,

aggravating such conditions.

(3) Milking parlor (facilities).

Ten farms do not have an appropriate place for this activity according to the requirements of Normative Instruction No. 62—IN 62 of Brazil. Consequently, a close relationship between the first EDI with this one is verified, regarding the presence of mud and waste near the milking site, as a consequence of the inadequacy of the farms' facilities.

(4) Incentives by governmental agencies.

In 12 surveyed farms, the unsatisfied dairy farmers criticized the inadequacy of public policies for milk-producing households. Although the government provided funding and development, excessive bureaucracy made access to these resources difficult.

This situation discouraged the permanence in this activity. Based on this context, credit lines were investigated and no clear and stable family farming policies were found. Again, the farmers' lack of schooling made it even more difficult to gain access to development.

(5) Working hours.

The dairy farmers reported intense workload, with no leisure time. This fact led to an investigation of the working day in the milking activity. It was found that they worked seven days a week without hiring a substitute, making weekly rest and/or vacations impossible. Thus, the lack of weekly rest and recovery of the musculoskeletal system left them permanently tired and with complaints of muscular pains. Accordingly, this item influenced the reports about the lack of stimulus to remain in the activity.

(6) Roads (access to the farms).

The difficulty of accessing the farms was pointed as having a negative impact on the activity. The poor quality of the municipal rural roads made it difficult to transit between rural and urban areas. This problem was aggravated mainly in the rainy season, damaging the milk collection. Irregularities on the roads were also detected: no pavement, narrow and eroded tracks, sand banks, slippery slopes due to mud accumulation, lack of maintenance, among others. Thus, losses occur due to the lack of milk transportation between the dairy farms and the factories when the roads are inaccessible.

(7) Price of the milk.

The price received for the milk was reported as discouraging by the producers. The value received per liter is not proportionally readjusted in relation to the increases in the input used in milk production (minerals, feed, medicines, etc.). There are seasons in which the remuneration does not cover the production cost expenses. This is aggravated because Brazil is facing serious economic problems, which have increased inflation and the value of the dollar. As a result, the farmers faced constant increases in

production costs, which led to a decline in profit margins, which were already small. The production cost is also influenced by climatic factors (e.g., excessive rainfall or drought), compromising the quality of the herd's pasture, resulting in the need for investment to purchase complementary nutrition (silage and feed).

(8) Technical assistance (production support).

The dairy farmers received no assistance due to the inefficiency of technical assistance provided by cooperatives, factories and public agencies (e.g., veterinarians, artificial insemination, milk production and quality enhancement, etc.). This situation, together with the low schooling level of the dairy farmers and the small profit margin of the activity, made it difficult to hire a veterinarian to solve the management problems that could result in lower calf mortality, lower cow abortion, false estrus, etc..

(9) Handling loads.

In general, the manipulation of loads is very present in the milk production activity. It was verified that these workers constantly carry out the lifting and loading of loads during milking (e.g., milk buckets and/or containers) and herd management (e.g., buckets with silage and sacks with grain and/or feed) for the treatment of the animals. It was verified that 37% of the dairy farmers suffered pain and/or discomfort in the musculoskeletal system due to their work. Thus, the characteristics of these pains and the affected body parts were investigated. The most affected region was the spine. About 70% of the dairy farmers reported pain in the lower back, 14.81% of whom used continuous pain relief drugs. One dairy farmer had already undergone surgery (due to disc herniation), being kept away from work activities during six months.

(10) Livestock health management.

Frequent (unplanned) additional costs were reported. This item is also related to the item "technical assistance", which also described the need for veterinarian assistance. There was concern in dealing with diseased animals and the treatment of diseases

(e.g., mastitis, hoof problems, mycoses, helminthiasis); control of parasites (e.g., ticks and flies); control of the cow's estrus and gestation period; birth process; control and eradication of brucellosis and bovine tuberculosis. According to the dairy farmers, compliance with legal requirements imposed by regulatory agencies (e.g., periodic examinations and mandatory vaccination) also causes concerns.

(11) Planning.

It has been found that lacks of plan and/or inadequate planning in the surveyed dairy farms are very common. The dairy farmers report that the

activity demands high daily workload and physical effort to fulfill the tasks of this activity, so the dairy farm's administration was conducted informally, based on their experience. Clearly, low schooling was again a limiting factor, since many farmers do not have any type of capacity to carry out planning and management.

The information recorded in Table 2 was illustrated (Fig. 2), the EDIs are interdependent. For this reason, they were grouped into three factors: infrastructure, management and public policies for the milk producing families.

Fig. 2 EDIs grouped into factors.

Fig. 3 Organization model of WRDF.

In the “infrastructure factor” group, the related EDIs were: hygiene and difficulty of accessing the vicinity of the milking place (Σ of the weight = 13); the facilities for performing the milking activity (Σ of the weight = 3.996); handling loads (Σ of the weight = 0.555), whose sum of the weight is 17.551.

In the “management factor”, the indicated EDIs were: herd’s handling (Σ of weight = 6.500); working hours (Σ of the weight = 1.400); road access to the farms (Σ of the weight = 0.996); livestock health management (Σ of weight = 0.500); planning (Σ of the weight = 0.180) with 9.576 as the sum of the weight.

For the “public policies factor” directed to milk producing families, the grouped EDIs were: incentive by governmental agencies (Σ of the weight = 2.500); price of the milk (Σ of the weight = 0.715); technical assistance (production support) (Σ of the weight = 0.625) amounting to a sum of the weight of 3.840.

It can be seen that the EDIs fall into two categories: internal problems that originate in the dairy farms proper, whose solution is (or could be) within reach of the rural families, and external problems, whose solution does not depend on the farmers or is out of reach of their control.

3.4 The Development of the Organization Model of WRDF

A dairy farm should be seen as a rural enterprise and as any venture: it needs to be economically viable to ensure its survival. In this context, based on the EDIs, the WRDF model was elaborated (Fig. 3). The

goal is for the WRDF model to encourage new discussions on the dairy sector of family dairy farms in Brazil (mid-western region of the state of Parana). It is believed that the implementation of the WRDF model would be able to assist in the adoption of measures that could improve the work organization, increasing productivity and quality of life for dairy farmers. Herewith, conditions could be given for the farmers to remain in the activity.

The WRDF model involves technical and social aspects. It is observed that in the model (Fig. 3), technical aspects directly influence the changes of infrastructure (physical facilities, machines, equipment and technology). The social aspects directly involve the management (intra and extra dairy farms) and the management of public policies destined to the milk producing families.

Regarding infrastructure, it is suggested that this factor should be a priority for future studies, since it presented the highest weight (Σ of the weight = 17.551) of the EDIs. Thus, studies on this factor should be a starting point.

Low-cost projects could be developed for the installation of milking parlors with automated equipment and technologies. From the implementation of this project, routines and working procedures could be improved. A low-cost facility could be adopted by these families and they could increase productivity as a result of the following factors: less working hours due to mechanization, reduction of embarrassing postures and need of physical efforts with the loads’

manipulation, less effort to sanitize the site, better animal welfare by decreasing the risk of diseases (e.g., mastitis), better milk quality and consequent better remuneration per produced liter by the buying factories.

Regarding the social aspect, the management factors refer to the diagnosis of the internal environment (herd management, working hours and planning). This would involve issues related to labor control, in the sense of management strategies involving plans and goals for the business, including the effective participation of the producer and his family. However, studies should also be carried out to deepen technical and economic knowledge (e.g., food management and dairy control, forage planting planning, herd management, management and control of the costs).

The public policies management factor refers to the external environment that impacts dairy farms. Although they significantly influence the performance of the rural enterprise, this factor is not controlled by the farmers. In this sense, research with collective actions (e.g., representative institutions) is needed, subsidizing the producers to request improvements in access to their farms, incentives, credit lines, development, training and technical assistance by government agencies, among other actions.

With this perspective, the WRDF model aimed to elucidate the aspects that are negatively interfering in the management of dairy farms in the surveyed region. It seeks to show the points that need to be addressed in technical, economic and financial issues in order to raise productivity and increase the farmers' income to maintain their farms economically viable.

Based on the context of problems and difficulties that farmers face, it is believed that the way each activity performed in the properties' daily routines determines the success of the enterprise. Thus, it is expected that the application of the model may help strengthen family farming.

As a result, the model will also show what points

should be addressed through training and technical assistance, which may have a greater impact on the productivity of the surveyed farmers.

4. Discussion

It has been found that many farms have been in business for a long time and still have low productivity. Due to the lack of infrastructure and management, and the limited access to technologies, these properties face difficulties in carrying out the activities in a productive, safe and efficient way—this reality has also been shown by other researches [14, 15].

The identification of the EDIs made it possible to diagnose that the low schooling level of the farmers and their families is still a very important factor in the management of properties and in relation to accessing incentive programs and credit lines, making it difficult to pursue infrastructure improvements and, consequently, a better price [16].

The inadequacy of the dairy farming facilities shows the same characteristics and problems reported by other authors. Reported in their studies on the physical load during load manipulation, on the squatting posture that causes pain in the spine (chest and lumbar region) and in the knees [9, 15, 17-20], and on the accumulation of mud and animal waste [15].

With respect to physical load, several studies in Europe and the USA have shown that dairy farms, even with high technology and a modern milking parlor due to mechanization still require physical loading and inadequate postures [11]. Therefore, the working class is prone to suffer pain and/or discomfort in the upper limbs [11, 21-24].

Thus, for the reality found in the surveyed dairy farms, meeting the need for technical, infrastructural and technological changes, helping farmers to reduce their workload, is not enough. To efficiently run their small farms, the farmers must learn to utilize fully and rationally the most abundant resources, saving the

scarcest; correctly introduce appropriate technologies and less dependent on external inputs; increase yields by area and per animal; produce larger and better surpluses for the market; add value to their products and reduce unit production costs [17].

5. Conclusions

As for the identification of the EDIs, 11 items were identified, the main ones being related to infrastructure issues, showing that it is the factor with the greatest need for immediate improvements.

For the construction of the WRDF model, the EDIs were organized into three categories: management, public policies management and infrastructure, which are subdivided into technical and social aspects. This model shows that in addition to investing in infrastructure and technologies, there is a strong lack in incentives and programs by the government, research institution and rural education that could foster and support family farms.

For future studies, this model can help identifying the categories that can be developed in new research with the purpose of creating the conditions to incorporate profitability and sustainability for the branch and helping in the improvement of the organization and the working conditions.

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