An examination of labour time-use on spring calving dairy farms in Ireland

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Abstract: *The seasonal workload associated with spring calving dairy farms, combined with increasing herd sizes has led to a renewed focus on labour time-use/ efficiency on dairy farms. The objective of this study was to examine labour time-use on spring calving Irish dairy farms in the spring and summer seasons. Eighty-two spring calving dairy farms completed the study from January to June 2019. Each farmer recorded their labour input on one alternating day each week using a smartphone app. Any farm worker not captured by the app was recorded through a weekly online survey. Farms with data for each month (n=72) were categorised into 1 of 4 herd size categories (HSC): farms with 50 to 90 cows (HSC 1); 91 to 139 cows (HSC 2); 140 to 239 cows (HSC 3); and ≥ 240 cows (HSC 4). For total farm hours, there was no statistical difference between HSC 1 (1883 h) and HSC 2 (2158 h), but predictably as HSC further increased, total farm hours increased (HSC 3: 2558 h, HSC 4: 3230 h). On a monthly basis, labour input peaked in February (16.5 h/ day) and March (16.9 h/ day).Total hours input by farmer and family were similar across HSCs. A greater proportion of work was completed by hired labour as HSC increased. The labour efficiency measure of h/cow improved as HSC increased (HSC 1: 27.5 h/ cow, HSC 2: 18.7 h/cow, HSC 3: 14.7 h/ cow, HSC 4: 11.6 h/ cow). 'Milking' was the most time consuming task representing 30% of farm labour input making it an important focus for potential improvements in efficiency. This study contributes to the understanding of labour use during the busiest time of the year for spring calving dairy farms, pointing to where greater labour efficiency gains can be made on farms.*

Keywords: *dairy farm labour, labour efficiency, time-use, seasonality*

Introduction

Employment in agriculture as a share of total employment has declined by 29.8% since 2000 as fewer people work on farms, particularly in developed countries (World Bank, 2019). Due to this reduced availability of workers, the management of labour input is becoming a crucial challenge for dairy farms internationally, especially in expanding dairy industries (Eastwood *et al.*, 2020; Kelly *et al.*, 2020). Following the removal of milk quotas in 2015, the Irish dairy industry expanded with increases in herd size resulting in a greater proportion of herds with more than 100 cows (23% in 2016 compared with 4.5% in 2005; Kelly *et al.*, 2020). This has led to an associated increased requirement for labour. Inter alia, this expansion has occurred due to the relative profitability of dairy farming compared with other agricultural sectors in Ireland, leading to larger and more specialised dairy farms (Buckley and Donnellan, 2020).

The additional workload driven by this expansion is compounded by the seasonality of pasture-based dairying, synonymous with Ireland, New Zealand, and parts of Australia and Western Europe. In this scenario seasonal calving and breeding protocols ensure that the maximum numbers of cows are in peak lactation to coincide with peak pasture growth (Roche *et al.*, 2017). This practice is associated with increased labour input during the calving period, with 57% of all farm workload occurring in the spring and summer seasons (Deming *et al.*, 2018) and labour input peaking in March and April (O'Donovan *et al.*, 2008). Similarly, September, October and November (spring in the Southern hemisphere) were the busiest months on a subset of New Zealand dairy farms (Taylor *et al.*, 2009). For pasture-based systems, a continued emphasis on compact calving signify that the condensed spring workload is likely to be exasperated further in the future (Shalloo *et al.*, 2014), with potentially greater requirements for extra seasonal labour input and productivity. An increased understanding of the spring workload is needed to address current and projected labour concerns in the dairy industry.

Labour productivity is a difficult subject to address as there are a number of influencing factors that are difficult to measure and define, and are often specific to individual farm situations. These include work practices (*e.g.* Gleeson *et al.*, 2007), work organisation (*e.g.* Hostiou and Dedieu, 2012), farm facilities (*e.g.* Næss and Bøe, 2011), technology use (*e.g.* Tarrant and Armstrong, 2012), and the use of contracting services (*e.g.* Deming *et al.*, 2019). Previous research measuring labour input on dairy farms has been limited, and focused specifically on labour efficient farms (Deming *et al.*, 2018); was undertaken during a time when milk quotas were in place (O'Donovan *et al.*, 2008); was carried out in New Zealand on larger scale farms (200 cows; Taylor *et al.*, 2009) not representative of the average Irish herd size at that time (58 cows); or used methodologies which included infrequent data recording (Powell, 2010). Semi-structured interviews have also been used to measure labour input (Hostiou and Dedieu, 2012, Cournut *et al.*, 2018). However, the time diary method used in the aforementioned studies is considered most accurate (Juster *et al.*, 2003, Schulz and Grunow, 2012), particularly if comparing farms (Cournut *et al.*, 2018). The diary operated through a smartphone app is an increasingly popular method of measuring time-use (Fernee and Sonck, 2013; Deming *et al.*, 2018), removing the opportunity for recall bias (Kjellsson *et al.*, 2014). To address the workload concerns on Irish dairy farms, a focused study was conducted to quantify labour demand and efficiency on dairy farms using the time diary method which would be representative of cow herd size and geographical location nationally. The objective of this paper is to examine labour time-use on spring calving, nationally representative Irish dairy farms in the spring and summer seasons using a smartphone app.

Materials and Method

Farmer Selection

Farmers were selected for this study based on the following criteria: predominantly spring-calving dairy farms with dairy as their primary enterprise; use a smartphone and be a Teagasc (the Irish public farm advisory service) client; and the sample of farmers would be proportionally selected based on the geographical distribution of dairy cow numbers and herd size categories (HSC).

Farms were categorised into four HSCs (50-90 cows; 91-139 cows; 140-139 cows; and ≥ 240 cows) representing 37%, 32%, and 21% and 10% of the national dairy cow population respectively (CSO, 2016) to ensure representation of a wide range of farm sizes. Herds of less than 50 cows were excluded as they were less likely to be full time specialist dairy farmers, and farms of this scale are declining in Ireland (CSO, 2013; CSO, 2016). Teagasc dairy farm advisors throughout Ireland were contacted to nominate suitable clients and 132 farmers were nominated with varying herd size and from various locations throughout Ireland. Nominated farmers were contacted by the researcher, the project was explained and their participation was requested. Eighty seven farmers fitting the aforementioned criteria agreed to participate. Five farmers were removed during the study due to data entry not being completed each week or the farmer requested to withdraw their participation.

The Smartphone Application

Data were collected using a time-use diary, operated through a smartphone app (developed by Acorn Agricultural Research). A description of the app and its functionality is described in Deming *et al.* (2018). Briefly, the app's design allowed farmers to record their labour data in real-time by starting and stopping a stopwatch function on the app as each designated task was started and completed. A list of the activities pertaining to each task (Table 1) was posted to the farmers prior to the study. Tasks were selected for the app based on Deming *et al.* (2018), but were reduced from 29 to 10 tasks by combining similar tasks. This was done to make the app more user friendly based on feedback from a focus group of farmers.

Each farmer operated the app along with any staff or family members working on the farm with access to a smartphone. App users inputted their labour task data in real-time during one (alternating) day each week (excluding Sundays due to time constraints) between January 22nd and June 29th, 2019.

Task	Definition
Administration/ business	Office work, advisory, staff management, sourcing materials, and trading dairy enterprise stock
Breaks	Breaks and non-farm activities
Calf care	Preparing/ transporting milk to calves, feeding milk/ forage/ supplement to calves pre-weaning, cleaning calf equipment, cleaning/ bedding calf sheds, tagging, and veterinary work with calves
Cow care	Cubicle cleaning/ bedding, cleaning yards/ passages, veterinary (cows), heat observation and AI, and calving/ monitoring cows
Feeding	Feeding forage/ supplement to livestock other than pre-weaned calves, and silage management (*e.g.* removing pit covers, opening baled silage)
Grassland management	Grassland measurement, strip fencing, fertiliser/ lime/ slurry/ FYM/ soiled water spreading, spraying, silage, reseeding, mowing, and topping
Heifer care	Herding, cubicle cleaning/ bedding, cleaning yards/passages, veterinary, and heat observation/ AI for heifers
Milking	Herding cows pre/ post milking, washing post milking, and milking
Other enterprises	Any other farm tasks not related to the dairy enterprise
Repairs & maintenance	Land and building maintenance, machinery maintenance, and milking machine maintenance

Table 1. Tasks on smartphone app and their definitions.

Weekly Survey

To capture other labour input by a labour person not using the app, a short weekly online survey was implemented. In addition, farmers were asked to input livestock details and hours of contractor work.

Data Checking and Adjustments

After each recording day, data from the app and online weekly survey was cleaned and checked for errors. Errors such as duplicate tasks, overlapping tasks and task durations (too long or too short) were checked and corrected where necessary by the researcher following communication with the farmer.

Calculations

Average monthly total labour input was obtained by summing the durations of each task across each day of data input for the month for both app and online survey data. This total was then divided by the number of recording days completed by the farmer for that month and multiplied by the total number of

working days in the month. This calculation is based on farmers working 6 full days per week and half day on Sunday. The half work day on Sunday is based on the premise that 95% of the participating farmers indicated that they 'completed main tasks' only. All 'breaks' were excluded.
Labour efficiency was measured as hours per cow (h/cow) as per previous studies (O'Donovan *et al.*, 2008; Næss and Bøe, 2011; Deming *et al.*, 2018). Average herd size was calculated using cow numbers (dry and milking) recorded through the online survey.

Statistical Analysis

Farms were assigned to one of the four aforementioned HSC's for analysis based on the average herd size. Of the 82 farm that completed the study, only those with data for each month were analysed (n=72) and are described in Table 2. Least square means among HSC were calculated for variables using linear models in PROC GLM procedures of SAS (SAS, 2014). Tukey's procedure was used for mean separation (P < 0.05).

	Herd size category				
Item	1	2	3	4	All farms
HSC parameter (cows)	50-90	91-139	140-239	≥240	
Average herd size (cows)	72	115	178	285	137
Herd size range (cows)	50-90	95-139	145-236	244-394	50-394
No. of farms	18	28	19	7	72

Table 2. Descriptive characteristics of farms within herd size categories (HSC) and all farms.

Results

Labour Input

Overall labour input contributed by each labour type and farm labour efficiency is presented in Table 3. Average labour input per farm was 2,299 hours **(h)** with an average herd size of 137 cows. For total farm hours, there was no statistical difference between HSC 1 and HSC 2 and so were regarded as 'similar', but predictably as HSC increased further, total farm hours increased (P < 0.05). Total farm hours varied considerably within each HSC demonstrating the variation that exists between farms of similar herd size. Average labour input by the farmer was 1,356 h and was similar for all HSCs. However, as HSC increased, the proportion of labour contributed by the farmer decreased from 69% for HSC 1 to 65%, 52% and 43% for HSCs 2, 3 and 4, respectively. Average labour contributed by family members was 419 h and did not significantly differ between HSC. As HSC increased, there was greater utilisation of hired staff (full time and part time). HSC 1 and HSC 2 used similar amounts of hired labour while HSC 4 used the largest amount and HSC 3 was intermediate (P < 0.05). Average contractor (outsourcing of work to external labour) input was 131 h, and was highest for HSC 3 and HSC 4 and lowest for HSC 1 (P < 0.01) with HSC 2 similar to all HSCs.
Average farm labour input per cow was 19.2 h/ cow. As HSC increased, farm labour input per cow decreased and was highest for HSC 1 compared with all other HSCs (P < 0.001), and HSC 2 was greater than HSC 4 (P < 0.05). There was a large range in farm labour efficiency within each HSC (HSC

1: 12.0 to 50.6 h/ cow; HSC 2: 12.1 to 32.2 h/cow; HSC 3: 8.7 to 19.6 h/ cow; and HSC 4: 7.6 to 13.2 h/ cow) which notably decreased as HSC increased.

	Herd size category[1]				*P-value*
Item	*1*	*2*	*3*	*4*	
Total farm labour input (h)	*1883 ^{a} (120)*	*2158 ^{a} (96)*	*2558 ^{b} (117)*	*3230 ^{c} (192)*	*<0.05*
Farmer (h)	*1305 (49)*	*1393 (40)*	*1337 (48)*	*1393 (79)*	*0.52*
Family (h)	*482 (105)*	*440 (84)*	*274 (102)*	*428 (168)*	*0.50*
Hired (h)	*27 ^{a} (75)*	*199 ^{a} (60)*	*778 ^{b} (73)*	*1192 ^{c} (120)*	*<0.05*
Contractor (h)	*68 ^{a} (22)*	*125 ^{ab} (18)*	*168 ^{b} (22)*	*216^{b} (35)*	*<0.05*
Labour efficiency (h/ cow)	*27.5 ^{a} (1.5)*	*18.7 ^{b} (1.2)*	*14.7^{bc} (1.4)*	*11.6 ^{c} (2.4)*	*<0.05*
Farmer (h/ cow)	*18.8 ^{a} (0.7)*	*12.3 ^{b} (0.6)*	*7.8^{c} (0.7)*	*5.0 ^{c} (1.1)*	*<0.001*

a-c Different superscripts indicate significant (P < 0.05) differences between herd size categories.

[1] 1 = farms with 50 to 90 cows (18 farms); 2 = farms with 91 to 139 cows (28 farms); 3 = farms 140 to 239 cows (19 farms); and 4 = farms ≥240 cows (7 farms).

Table 3. Farm labour input (± standard error) and Labour efficiency (± standard error) on farm across herd size categories for the study period (January – June).

The Farmers' Working Day

Details of the farmers' working day for the study and for February/ March are presented in Table 4. For the farmer, average start and finish times were 06:55 and 18:56. There were no significant differences between HSC's for start and finish times, length of day, 'non-farm activity' (all breaks and off-farm activity during the farmers' working day), and length of working day excluding 'non-farm activity'. Ranges were large for all variables. Average start and finish times were 06:54 and 19:03 for February/ March. Farmers worked on average 59.0 h/ week for the study period. In February/ March, they worked 63.4 h/ week compared with an average of 56.4 h/ week in the other months of the study.
Farmer hours worked per day (10.0 h/ day) peaked in March and were lowest in January (7.4 h/ day) and June (8.2 h/ day). In February, farmers in HSC 1 (8.5 h/ day) worked fewer h/ day than HSC 3 (10.3 h/ day) and HSC 4 (10.6 h/ day; $P < 0.05$), and tended to work fewer than HSC 2 (9.7 h/ day; $P = 0.06$). From March onwards, farmers in all HSCs worked similar h/ day.

Monthly Effects

Peak labour input occurred in February and March on 54% (n = 39) of farms, while it occurred in May and June on 44% (n = 31), with 77% (n = 24) of these latter farms in HSC 1 and HSC 2.
Daily farm labour input is shown in Table 5. Daily labour input increased from 12.2 h/ day in January to 16.5 h/ day and 16.9 h/ day in February and March before declining in April (14.7 h/ day) and rising again in May (15.6 h/ day) followed by a decrease to 14.3 h/ day in June. Herd size category had a significant effect on labour input h/day for each month.

	Herd size category[1]				Study average[2]	Range	P-value
Full study period	1	2	3	4			
Start time (h)	06:59	06:54	06:56	06:40	06:55	05:47 - 09:13	0.65
Finish time (h)	19:00	19:04	18:51	18:17	18:56	17:05 - 21:41	0.37
Length of working day (h/ day)	12	12.2	11.9	11.8	12	9.9 - 14.2	0.67
Non-farm activity (h/day)	4.1	3.7	3.8	3.5	3.8	2.2 - 5.6	0.12
Length of working day excluding non-farm activity (h/day)	7.9	8.5	8.1	8.3	8.2	5.7 - 11.0	0.41
February/March							
Start time (h)	06:56	06:56	06:58	06:34	06:54	04:34 – 09:07	0.58
Finish time (h)	19:05	19:06	19:00	18:49	19:03	17:15 – 22:26	0.90
Length of working day (h/ day)	12.2	12.2	12.0	12.3	12.1	8.5 – 15.0	0.95
Non-farm activity (h/day)	4.0^{a}	3.4^{ab}	3.1^{b}	3.3^{ab}	3.4	1.8 – 6.3	<0.05
Length of working day excluding non-farm activity (h/day)	8.2	8.8	9.0	8.9	8.7	5.4 - 11.8	0.24

$^{a\text{-}b}$ Different superscripts indicate significant (P < 0.05) differences between herd size categories.

[1] 1 = farms with 50 to 90 cows (18 farms); 2 = farms with 91 to 139 cows (28 farms); 3 = farms 140 to 239 cows (19 farms); and 4 = farms ≥240 cows (7 farms).
[2] The average of all farms used in the analysis (n = 72).

Table 4. Descriptive characteristics of the farmers' working day across herd size category for the study period (January to June) and February/March.

	Herd size category[1]				*Pooled standard error*	*Study average[2]*	*P-value*
Item	*1*	*2*	*3*	*4*			
January	10.0^{a}	11.0^{ab}	14.0^{bc}	18.1^{c}	1.2	12.2	<0.05
February	12.6^{a}	14.7^{a}	19.9^{b}	24.5^{b}	1.1	16.5	<0.001
March	13.6^{a}	15.0^{a}	20.0^{b}	24.8^{b}	1.2	16.9	<0.001
April	12.7^{a}	13.8^{ab}	16.1^{bc}	19.7^{c}	1.0	14.7	<0.05
May	12.9^{a}	15.7^{a}	15.6^{a}	22.7^{b}	1.1	15.6	<0.001
June	12.1^{a}	14.3^{ab}	15.2^{ab}	17.7^{b}	1.2	14.3	<0.05

a-b Different superscripts indicate significant (P < 0.05) differences between herd size categories.

[1] 1 = farms with 50 to 90 cows (18 farms); 2 = farms with 91 to 139 cows (28 farms); 3 = farms 140 to 239 cows (19 farms); and 4 = farms ≥240 cows (7 farms).

[2] The average of all farms used in the analysis (n = 72).

Table 5. Average total hours of farm labour per day for each herd size category (HSC) in each month of the study.

Tasks

The percentage of time devoted to each task (including tasks conducted by contractors) as a proportion of all farm labour input is presented in Figure 1. 'Milking' was the most time-consuming task on farms, representing 679 h of total farm labour input in the January - June period. Following 'milking', the remaining time consuming tasks were: 'calf care' (311 h); 'grassland management' (281 h); 'cow care' (249 h); 'repairs & maintenance' (240 h); 'administration/ business' (183 h); 'feeding' (91 h); 'heifer care' (72 h); and 'other enterprises' (61 h). Work completed by contractors accounted for the remaining share of all labour input (131 h).

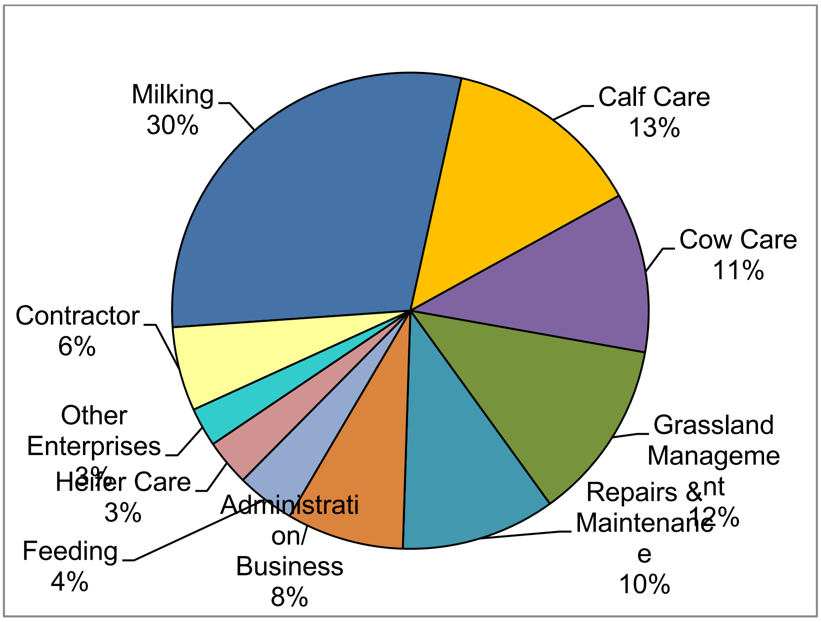

Figure 1. Breakdown of time spent at each task and contractor input as a proportion of all farm labour input for the study period (January to June).

Total hours input for each task across HSC is shown in Figure 2. Herd size category 4 spent the most time (952 h) at 'milking', HSC 1 (592 h) and HSC 2 (618 h) the least, and HSC 3 (752 h) was intermediate ($P < 0.05$).

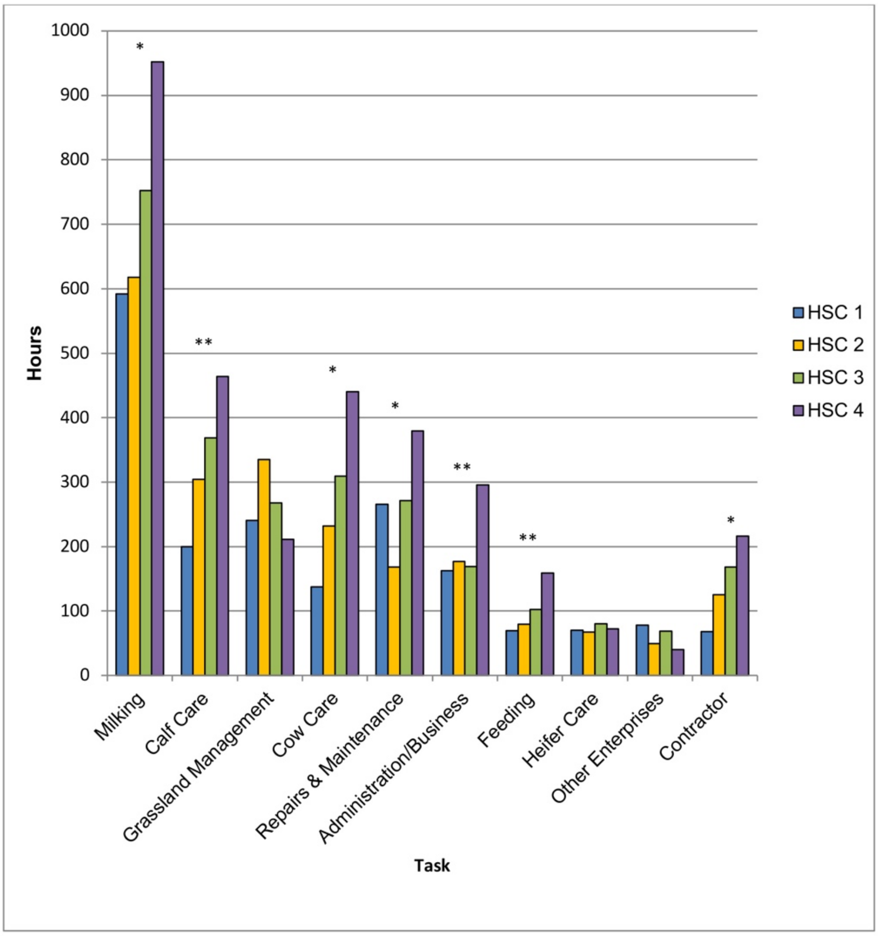

Figure 2. Time spent at each task across herd size category (HSC) for the study period (January to June). *HSC 1 = 50-90 cows; HSC 2 = 91-139 cows; HSC 3 = 140-239 cows; and HSC 4 = ≥240 cows. * indicates significant difference * = P < 0.05; ** = P < 0.01; and *** = P < 0.001;*

Monthly labour input per task is shown in Figure 3. The 'milking' task was the most time-consuming task for each month except January during which it was 'cow care'. 'Calf care' and 'cow care' tasks were at their most time consuming in February and March and declined in April, May, and June. Conversely, time spent at 'grassland management' increased as the study progressed peaking in June. In February and March, when total labour input was highest, 'repairs & maintenance' work was at its lowest. Hours per day spent 'feeding' declined as the study progressed coinciding with the end of the winter housing period for cows. 'Administration/ business', 'heifer care' and 'other enterprises' required consistent time inputs through each month of the study. Tasks conducted by contractors accounted for a considerably higher proportion of overall h/ day in May and June than in the previous months.

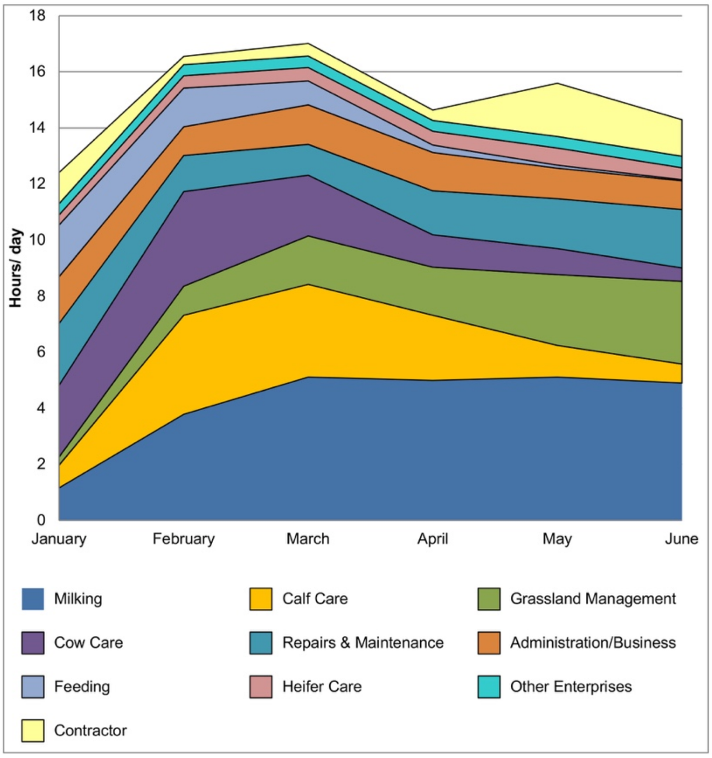

Figure 3. Average labour input (h/ day) for each task for each month of the study on all farms (n=72)

Discussion

This research examined labour time-use in the spring and summer seasons, using more frequent recordings than O'Donovan *et al.* (2008) and Deming *et al.* (2018) who recorded on three set days each month. Increased recordings on alternative days each week allowed for the capture of a more diverse range of tasks undertaken on farms, whereas recording on three set days may not have captured all work where the farmer worked to a specific routine. A challenge for previous time-use studies has been finding the balance between the level of detail required and recording regularity, and attracting and retaining farmers (Taylor *et al.*, 2009, Powell, 2010, Deming *et al.*, 2018). The reduction in tasks compared with previous studies (Taylor *et al.*, 2009, Deming *et al.*, 2018) allowed for a holistic view of time input to the main farm tasks making for a more user friendly experience, as indicated by the high retention of farmers on the study.

Labour input peaked in February and March with either month being the busiest on 55% of farms. As a result, they require more focus for potential labour savings as improvements that can be achieved in these two months would aid in supressing the seasonal nature of labour demand. More detailed task measurements to ascertain how the most labour efficient farmers allocate their time in these two months could offer substantial benefits to farmers highlighting where time saving could be made. May and June were the months of peak labour input on 44% of farms which in part was due to the large input of contractors (mainly for silage harvesting). However, there is also a possibility that with the majority of these farmers in HSC 1 and HSC 2 they were expanding their work to fill the day, as suggested by Deming *et al.* (2018). Alternatively, as these are mainly single operator farms, non-essential work in spring may have been postponed until later in the year. The differences between the minimum and maximum months for labour input increased as HSC increased, indicating greater peaks and troughs in labour demand on larger farms. For larger farms, improved springtime productivity to address the peaks and troughs is important, particularly with increased difficulty in attracting labour to work on dairy farms (Eastwood *et al.*, 2020) and the associated cost of additional labour.

As HSC increased there was an associated increase in labour input required, which was supplied by contractors and particularly hired labour, corroborating the findings of O'Donovan *et al.* (2008) and Deming *et al.* (2018). However, for HSC 1 and HSC 2 there was no significant difference in total labour input and they were predominately dependent on the farmers own labour. This may be due to a greater use of labour saving technologies and practices on HSC 2 farms when compared with HSC 1 (*e.g.* automatic cup removers, contract heifer rearing). Furthermore, larger farms are more likely to mechanise routine tasks as a means of reducing workload (Hostiou and Dedieu, 2012).

Labour efficiency (h/ cow) improved with increasing herd size similar to previous studies (O'Donovan *et al.*, 2008; Deming *et al.*, 2018). There is a positive interaction between increased herd size, and farm management practices, facilities and work organisation (Tauer, 2001; Cournut *et al.*, 2018) as larger farms are more likely to be the first adopters of new innovations partly because they benefit the greatest (Läpple *et al.*, 2015, Gargiulo *et al.*, 2018). These greater levels of technology adoption may reflect attempts to address labour issues on larger farms (Gargiulo *et al.*, 2018). Another contributing factor is that some tasks may take a similar amount of time regardless of herd size (*e.g.* herding heifers). Most importantly however, there is an economy of scale effect (in terms of h/ cow) resulting in many smaller farms having difficulty in achieving similar levels of labour efficiency to larger farms. Therefore, setting attainable benchmarks within HSCs would benefit farmers to set goals regarding labour efficiency.

Labour input and efficiency varied considerably between herds within different HSCs, and this variation decreased with increased HSC, similar to Næss and Bøe (2011); highly efficient farms as well as farms with scope for improvement were identified in each HSC. Gaining a greater understanding of why individual farms within each HSC were more labour efficient than others by identifying their work practices, facilities and work organisation could help to achieve improved labour efficiency.

Farmers consider quality of life, time-off, and time with family as measures of success (Russell and Bewley, 2013), yet the farmers in this study worked an average of 59 h/ week for the study period and 63 h/ week in February/ March. These figures were greater than Deming *et al.* (2018), who found that farmers worked 56 h/ week in spring (February, March, and April). Deming *et al.* (2018) purposely selected for labour efficient farmers and that may explain the difference in results. Working long hours is a significant risk factor regarding health and safety on farms (Osborne *et al.*, 2010). Recognising the need to address working week length in the industry, the Workplace Action Plan in New Zealand aims to have farm operators working a maximum of 48 h/ week (Dairy NZ, 2020). A similar benchmark may be useful in Ireland to place increased emphasis on farmer work/ life balance and ultimately reduce hours worked. Addressing the workload of the farmer will be increasingly important as many adolescents perceive dairy farming careers negatively because of a poor work/life balance (Beecher *et al.*, 2019). Understanding how the most labour efficient farmers manage their spring working hours would offer insights into how dairy farmers can improve their own individual situations and make dairy farming more attractive as a career.

Although start and finish times were similar across HSCs, there were numerical differences. Farmers in HSC 4 started 19 minutes earlier than HSC 1 and finished 47 minutes earlier than HSC 2. The earlier times may have been influenced by the presence of hired labour on larger farms. There was little fluctuation in start and finish times throughout the study, suggesting that farmers worked to a routine

and took more time for 'non-farm activity' during the day when labour demand was low as opposed to starting later in the morning or finishing earlier in the evening. This is possibly because farmers were trying to maintain milking intervals close to 12 hours, even though O'Brien *et al.* (1998) found that milk yield and composition were not affected by changing milking intervals from 12:12h to 16:8h. The flexibility within a farmer's working day can also be interpreted as a positive aspect of dairy farming as work flexibility is increasingly appreciated by both employers and employees (White *et al.*, 2003) and could be used to differentiate a career in farming compared with other industries.
As the most time-consuming task, 'milking' represents the task where most gains in labour efficiency could be made. The proportion of labour dedicated to milking ranged from 32% to 57% in other pasture-based dairy studies (O'Donovan *et al.*, 2008; Taylor *et al.*, 2009; Deming *et al.*, 2018). HSC 1 and HSC 2 farmers spent a similar amount of time at 'milking' suggesting that milking facilities in HSC 1 may be less labour efficient. As milking was generally a one-person task on these farms, there is less room to improve efficiency without increasing the number of milking units (O'Brien *et al.*, 2006). It can be more difficult to justify the investment in technologies on these relatively smaller farms (Tarrant and Armstrong, 2012), and opportunities for labour efficiency improvements in smaller milking facilities through technology can be limited compared with larger dairies (Dela Rue *et al.*, 2020).
In February and March, 'calf care' and 'cow care' accounted for a substantial quantity of labour input. Deming *et al.* (2018) found that early turnout of calves to grass and keeping calves in group calf pens from birth represented practices associated with the most labour efficient farms. Automatic calf feeders and once-a-day milk feeding are other potential labour saving options for 'calf care' (Gleeson *et al.*, 2008). With regard to 'cow care', Gleeson *et al.* (2007) established that restricting silage access until evening feeding reduced the number of night time calving's. However, further labour-saving ideas are needed for this task which accounts for a large amount of time during peak labour demand. There were no significant differences in time spent at 'grassland management' between HSCs and it is likely that this is accounted for by the greater time input by contractors for grassland management on HSC 3 and 4 farms. The 'administration/ business' task was similar for HSC 1, HSC 2, and HSC 3 but the large increase in time spent at this task by HSC 4 farmers would imply that more time is spent at business and strategic management where farms have full time staff covering day-to-day operational tasks, similar to Hadley *et al.* (2002).

Conclusion

This study contributes to our understanding of labour use during the busiest time of the year for spring calving dairy farms in Ireland and points to where greater labour efficiency gains can be made. The results can also be applied to aid seasonal calving systems internationally where labour input peaks during the calving period. The large variation in farm labour efficiency underlines the requirement for a greater focus on knowledge transfer of methods to achieve better work-life balance and improved labour efficiency on many dairy farms. In a wider context, the flexibility of farmer working hours relative to other sectors should be highlighted to differentiate farming as a career choice, while the many farms that are achieving high levels of labour efficiency and work life balance in springtime should be emphasised. Herd size does not impede farmers from becoming more labour efficient and further investigation into the facilities, work practices and organisation being implemented by the most labour efficient farmers could establish best practice for each HSC and further labour-saving ideas. As February and March were the two busiest months on most dairy farms, they require the most focus for identification of potential labour savings. With 'milking' accounting for 35% of total time use between March and June, this task represents an important focus for improvements in labour efficiency on dairy farms. Finally, this paper highlights hours labour per cow as a useful measure of labour efficiency to compare farms of different scale. However, this measure gives no indication of farm productivity or profitability so further work should investigate the impact of labour efficiency on such farm key performance indicators.

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