The seasonal workload associated with pasture-based dairy farms, combined with increasing herd sizes, has led to a renewed focus on labor time-use and efficiency on dairy farms. The objective of this study was to examine labor time-use on pasture-based dairy farms in the spring and summer seasons. A total of 82 spring-calving Irish dairy farms completed the study from February 1 to June 30, 2019 (150 d). Each farmer recorded their labor input on one alternating day each week using a smartphone app. Any labor input by farm workers not using the app was recorded through a weekly online survey. Farms with data for each month (n = 76) were classified into 1 of 4 herd size categories (HSC) for analysis: 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). Total hours of labor input was similar on HSC 1 (1,821 h) and HSC 2 (2,042 h) farms, but predictably as HSC increased further, total hours of labor input increased (HSC 3: 2,462 h, HSC 4: 3,040 h). On a monthly basis, labor input peaked in February (15.4 h/d) and March (15.7 h/d). The farmer worked on average 60.0 h/wk over the duration of the study period. Hired labor and contractors completed a greater amount of work as HSC increased. Labor efficiency, as measured by hours/cow, improved as HSC increased (HSC 1: 26.3 h/cow, HSC 2: 17.7 h/cow, HSC 3: 14.3 h/cow, HSC 4: 10.9 h/cow), though there were large variations in labor efficiency within HSC. Milking was the most time-consuming task, representing 31% of farm labor input making it an important focus for potential improvements in efficiency. The next 5 most time-consuming tasks were calf care (14%), grassland management (13%), cow care (10%), repairs and maintenance (10%), and administration/business (8%). This study contributes to the understanding of labor use during the busiest (most labor demanding) time of the year on pasture-based dairy farms and points to areas where labor efficiency improvements can be made on farms. The considerable variation in farm labor efficiency observed within HSCs emphasizes the necessity for a greater focus on knowledge transfer of methods to achieve improved labor efficiency and a better work-life balance on many dairy farms. As the 2 busiest months on most dairy farms, February and March require the most focus for identification of potential labor savings.

Key words: dairy farm labor, labor efficiency, time-use, seasonality

INTRODUCTION

Globally, dairy producers are facing increased challenges regarding sustainability, while continuing to meet increasing demand for nutritious and affordable food (Miller and Auestad, 2013; Arvidsson Segerkvist et al., 2020). Dairy systems must now focus on more sustainable production that reflects the economic, environmental and social goals of society (Latruffe et al., 2016). Pasture-based dairying, practiced in Ireland, New Zealand, and parts of Australia and Western Europe, has the potential to meet these demands. In this scenario, breeding protocols and seasonal calving ensure that peak lactation coincides with peak pasture growth for as many cows as possible in the herd (Roche et al., 2017). This system allows farms to maintain high levels of profitability, largely due to the strong inverse relationship between production costs and pasture utilization per hectare (Ramsbottom et al., 2015). Additionally, the environmental impact associated with milk production in pasture-based systems compares favorably with other dairy systems where cows are kept indoors (O’Brien et al., 2012). However, the social dimension of sustainability, including working hours and quality of life, is often overlooked (Arvidsson Segerkvist et al., 2020), in part due to these measures being subjective and difficult to quantify (Latruffe et al., 2016).

Employment in agriculture as a share of total employment has declined by 29.8% since 2000 as fewer people work on farms, particularly in Organization for Economic Co-operation and Development member countries (World Bank, 2019). Due to this reduced availability of workers, the management of labor in-
put is becoming a crucial challenge for dairy farms internationally, especially in expanding dairy industries (Eastwood et al., 2018; Kelly et al., 2020). Following the removal of EU milk quotas in 2015, the Irish dairy industry expanded, 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 labor input. Among other factors, this expansion has occurred due to the relative profitability of dairy farming compared with other agricultural sectors, leading to larger and more specialized dairy farms (Buckley and Donnellan, 2020).

The seasonal workload associated with pasture-based dairying is a challenge that has been compounded by the recent herd size expansion (Kelly et al., 2020). Increased labor input is associated with calving and calf care, and much of this occurs during spring and early summer; 57% of all farm workload occurs in the spring and summer seasons (Deming et al., 2018) and labor input peaks in March and April (O’Donovan et al., 2008). Similarly, September, October, and November (springtime in the Southern hemisphere) were the busiest months on a subset of New Zealand dairy farms (Taylor et al., 2009). A continued emphasis on compact calving in pasture-based systems means that the condensed spring workload is likely to be maintained (Shalloo et al., 2014), with potentially greater requirements for additional seasonal labor input and productivity. Simultaneously, even the most labor efficient farmers are working 56 h/wk during this period (Deming et al., 2018), and the intense workload has been cited as a source of stress and mental health issues among farmers (Lunner Kolstrup et al., 2013). This, combined with current and projected labor concerns in the dairy industry signifies that an increased understanding of the springtime workload is required. Improved time-use in spring and summer, resulting in reduced work hours, can have associated positive effects on many aspects of dairy farming; including the health and safety of farm operators (Osborne et al., 2010), reduced stress and fatigue among farmers (Kallioniemi et al., 2016), creating more attractive workplaces (Eastwood et al., 2018), and improving farm profitability (Hemme et al., 2014).

Labor productivity is a difficult topic to address as there are several influencing factors that are difficult to define and measure, and are often specific to individual farm situations. These include work practices (Gleeson et al., 2007), work organization (Hostiou and Dedieu, 2012), farm facilities (Næss and Boe, 2011), technology use (Tarrant and Armstrong, 2012), and the use of contracting services (Deming et al., 2019). Previous research regarding the measurement of labor input on dairy farms has been limited. In Ireland, Deming et al. (2018) measured labor input on select labor efficient farms, and the work of O’Donovan et al. (2008) was undertaken when EU milk quotas were in place and dairy herd sizes were smaller relative to 2021. Internationally, research in New Zealand was completed on a small sample of large-scale farms (Taylor et al., 2009) not representative of the average Irish herd size at that time, and other research completed has used methodologies involving infrequent data recording (Powell, 2010). Semi-structured interviews have also been used to measure labor 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 increasingly popular method of measuring time-use (Fernee and Sonck, 2013; Deming et al., 2018) as it removes the opportunity for recall bias (Kjellsson et al., 2014) and reduces the amount of manual data input and management required.

It was considered that a detailed assessment of the current springtime workload on pasture-based dairy farms was required to address seasonal workload concerns. Previous research has highlighted the effect of herd size on labor time-use and efficiency; as herd size increases, overall time input increases and labor efficiency improves (O’Donovan et al., 2008; Cournut et al., 2018; Deming et al., 2018). Therefore, a focused study was conducted to quantify labor demand and efficiency using the time diary method on a sample of Irish farms, grouped into herd size categories (HSC) such that they would be representative of dairy herd size nationally.

**MATERIALS AND METHODS**

Ethical approval for this study was granted by the Human Research Ethics Committee of University College Dublin, Ireland (LS-E-19–13-Hogan-Kinsella).

**Farmer Selection**

Farms were selected to be proportionally represented within HSC. The 3 criteria required to take part in this study were (1) that the farmer (owner operator) had access to a smartphone; (2) the farmer was a Teagasc (The Irish Agriculture and Food Development Authority) client with dairy as their main farm enterprise; and (3) the farm had a herd size of >50 cows. 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, 2016). Farms were categorized into 4 HSC (HSC 1: 50–90...
cows; HSC 2: 91–139 cows; HSC 3: 140–239 cows; and HSC 4: 240 cows) to ensure representation of a wide range of farm sizes. Herd size categories 1 and 2 represented 37 and 32% of the national dairy cow population, respectively (CSO, 2016). Herd size categories 3 (21%) and 4 (10%) accounted for the remaining 31%. These latter 2 categories were established because of the considerable variation in labor efficiency observed on farms with herd sizes >139 cows (Deming et al., 2018). The sampling strategy ensured a wide range of farm sizes and farms across all levels of labor efficiency. 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 agreed to participate. Five farmers were removed during the study due to data entry not being completed each week or the farmer requesting 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 labor data in real-time by starting and stopping a stopwatch function on the app as each designated task was commenced and completed. A list of the activities pertaining to each of the 10 tasks on the app (Table 1) was sent to each farmer before the study commenced. 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 modification was based on feedback from a focus group of farmers and made the app more user friendly.

Each farmer operated the app as well as any staff or family members working on the farm with access to a smartphone. App users inputted their labor task data in real-time during one (alternating) day each week (excluding Sundays to minimize the time impact and inconvenience on participants) between February 1 and June 30, 2019 (150 d).

**Weekly Online Survey**

Labor input by persons not using the app and hours of contractor work were captured through an online survey completed after each recording day, and then incorporated with the smartphone app data. In addition, farmers were asked to input livestock details regarding the number of dry and milking cows on the farm on the recording day, which were averaged over the period to calculate the farms’ herd size.

**Data Checking and Adjustments**

Following every recording day, data from the app and online survey were 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**

Monthly task labor input was obtained by summing the duration of time spent at each individual task across each day of data input for the month for both app and online survey data (all breaks were excluded). This total was then divided by the number of record-

<table>
<thead>
<tr>
<th>Task</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration and business</td>
<td>Office work, advisory, staff management, sourcing materials, and trading dairy enterprise stock</td>
</tr>
<tr>
<td>Breaks</td>
<td>Breaks and nonfarm activities</td>
</tr>
<tr>
<td>Calf care</td>
<td>Preparing or transporting milk to calves; feeding milk, forage, or supplement to calves preweaning; cleaning calf equipment; cleaning or bedding calf sheds; tagging; and veterinary work with calves</td>
</tr>
<tr>
<td>Cow care</td>
<td>Cubicle cleaning or bedding, cleaning yards or passages, veterinary (cows), heat observation and AI, and calving or monitoring cows</td>
</tr>
<tr>
<td>Feeding</td>
<td>Feeding forage or supplement to livestock other than preweaning calves, and silage management (e.g., removing pit covers, opening baled silage)</td>
</tr>
<tr>
<td>Grassland management</td>
<td>Grassland measurement, strip fencing, spraying, silage, reseeding, mowing, topping, and spreading fertilizer, lime, slurry, farmyard manure, or soiled water</td>
</tr>
<tr>
<td>Heifer care</td>
<td>Herding, cubicle cleaning or bedding, cleaning yards/passages, veterinary, and heat observation and AI for heifers</td>
</tr>
<tr>
<td>Milking</td>
<td>Herding cows before and after milking, washing postmilking, and milking</td>
</tr>
<tr>
<td>Other enterprises</td>
<td>Any other farm tasks not related to the dairy enterprise</td>
</tr>
<tr>
<td>Repairs and maintenance</td>
<td>Land and building maintenance, machinery maintenance, and milking machine maintenance</td>
</tr>
</tbody>
</table>
ing days completed by the farmer for that month and multiplied by the total number of working days in the month. This calculation was based on farmers working 6 full days per week and a half day on Sunday. A half day is based on the premise that 95% of the participating farmers indicated that they completed main tasks only on a Sunday. Total task labor input was obtained by summing the time spent at each task per month. Total farm hours were similar for HSC 1 and HSC 2, but predictably as HSC increased further, total farm hours increased \((P < 0.001)\). Total farm hours varied considerably within each HSC demonstrating the variation that exists between farms of similar herd size. Average labor input by the farmer was 1,285 h and was similar for all HSC. However, as HSC increased, the proportion of labor contributed by the farmer decreased from 67% for HSC 1 to 64, 53, and 43% for HSC 2, 3, and 4, respectively. Average labor contributed by family members was 425 h and did not differ between HSC. As HSC increased, there was greater utilization of hired staff (full time and part time). Herd size categories 1 and 2 used similar levels of hired labor, whereas HSC 4 used the largest amount and HSC 3 was intermediate \((P < 0.001)\). Average contractor (outsourcing of work to external labor) input was 121 h, and was highest for HSC 3 and HSC 4 and lowest for HSC 1 \((P = 0.004)\).

Average farm labor input per cow was 18.2 h/cow. As HSC increased, farm labor input per cow decreased and was highest for HSC 1 compared with all other HSC, and HSC 2 was greater than HSC 4 \((P < 0.001)\). A considerable range in farm labor efficiency was observed within each HSC (HSC 1: 11.8–47.9 h/cow; HSC 2: 11.7–29.9 h/cow; HSC 3: 8.5–19.7 h/cow; and HSC 4: 7.2–12.5 h/cow), which notably decreased as HSC increased.

### Statistical Analysis

Farms were assigned to one of the 4 aforementioned HSC for analysis based on their average herd size. Of the 82 farms that completed the study, only those with data for each month (February to June) were analyzed \((n = 76)\) and are described in Table 2. Least squares means among HSC were calculated for variables using linear models in PROC GLM procedures of SAS (version 9.4., SAS Institute). The Tukey-Kramer multiple range test was used for mean separation \((P < 0.05)\).

### Disclaimer

Preliminary results from this data set were presented at the 2nd International Symposium of Work in Agriculture in 2021 and published in the associated proceedings (Hogan et al., 2021). The results from that publication were from preliminary analysis of the data, whereas the results presented here represent a more in-depth analysis and delve further into the discussion and implications of the study.

### RESULTS

#### Labor Input

Farm labor input contributed by each labor type and farm labor efficiency are presented in Table 3. Average labor input per farm was 2,200 h with an average herd size of 137 cows. Total farm hours were similar for HSC 1 and HSC 2, but predictably as HSC increased further, total farm hours increased \((P < 0.001)\). Total farm hours varied considerably within each HSC demonstrating the variation that exists between farms of similar herd size. Average labor input by the farmer was 1,285 h and was similar for all HSC. However, as HSC increased, the proportion of labor contributed by the farmer decreased from 67% for HSC 1 to 64, 53, and 43% for HSC 2, 3, and 4, respectively. Average labor contributed by family members was 425 h and did not differ between HSC. As HSC increased, there was greater utilization of hired staff (full time and part time). Herd size categories 1 and 2 used similar levels of hired labor, whereas HSC 4 used the largest amount and HSC 3 was intermediate \((P < 0.001)\). Average contractor (outsourcing of work to external labor) input was 121 h, and was highest for HSC 3 and HSC 4 and lowest for HSC 1 \((P = 0.004)\).

Average farm labor input per cow was 18.2 h/cow. As HSC increased, farm labor input per cow decreased and was highest for HSC 1 compared with all other HSC, and HSC 2 was greater than HSC 4 \((P < 0.001)\). A considerable range in farm labor efficiency was observed within each HSC (HSC 1: 11.8–47.9 h/cow; HSC 2: 11.7–29.9 h/cow; HSC 3: 8.5–19.7 h/cow; and HSC 4: 7.2–12.5 h/cow), which notably decreased as HSC increased.

### The Farmers’ Working Day

Details of the farmers’ working day for the study, and for February and March, are presented in Table 4. Average start and finish times (of the farmer) were 0649 h and 1858 h, respectively. There were no difference between HSC for start and finish times, length of day, and length of working day excluding nonfarm activity; however, HSC 1 tended to have a greater amount of nonfarm activity (all breaks and off-farm activity during the farmers’ working day) than HSC 2 \((P = 0.07)\) over the full study period. Additionally, HSC 1 had more nonfarm activity than HSC 3 \((P = 0.008)\) in February and March; this contributed to HSC 1 having a shorter working day (excluding nonfarm activity) than HSC 3 \((P = 0.05)\). Ranges were large for all variables. Average start and finish times were 0654 h and 1903 h,
respectively, for February and March. Farmers worked on average 60.0 h/wk over the complete study period, whereas they worked 63.5 h/wk in February and March, and 57.7 h/wk during the remaining 3 mo of the study.

Hours worked per day by the farmer peaked in March (9.5 h/d) and was lowest in June (7.3 h/d). In February, farmers in HSC 1 (7.8 h/d) worked fewer h/d than HSC 2 (9.0 h/d), HSC 3 (9.6 h/d) and HSC 4 (9.8 h/d; \(P < 0.001\)). From March onward, farmers in all HSC worked similar hours per day.

**Monthly Effects**

Peak labor input occurred in February and March on 50\% (n = 38) of farms, whereas it occurred in May and June on 45\% (n = 34), with 79\% (n = 27) of these latter farms in HSC 1 and HSC 2.

Daily farm labor input during each month of the study is shown in Table 5. Daily labor input peaked in February and March at 15.4 h/d and 15.7 h/d before declining in April (14.0 h/d) and rising again in May (14.9 h/d) followed by a decrease to 13.4 h/d in June. Herd size category had an effect (\(P < 0.001\)) on farm hours worked per day in February, March, April, and May.

**Tasks**

The percentage of time devoted to each task (including tasks conducted by contractors) as a proportion of all farm labor input is presented in Figure 1. Milking was the most time-consuming task on farms, consuming an average of 4.5 h/d in the February to June period. Following milking, the remaining tasks in order of time consumption were calf care (2.0 h/d); grassland management (1.9 h/d); cow care (1.5 h/d); repairs and maintenance (1.5 h/d); administration and business (1.1 h/d); feeding (0.5 h/d); heifer care (0.4

---

### Table 3. Farm labor input (±SE) and labor efficiency (±SE) across farms in each herd size category (HSC)\(^1\) for the study period from February 1 to June 30 (150 d)

<table>
<thead>
<tr>
<th>Item</th>
<th>HSC 1</th>
<th>HSC 2</th>
<th>HSC 3</th>
<th>HSC 4</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total farm labor input (h)</td>
<td>1,821(^a) (113)</td>
<td>2,042(^a) (93)</td>
<td>2,462(^b) (105)</td>
<td>3,040(^c) (186)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Farmer</td>
<td>1,226 (45)</td>
<td>1,315 (37)</td>
<td>1,295 (42)</td>
<td>1,298 (74)</td>
<td>0.48</td>
</tr>
<tr>
<td>Family</td>
<td>505 (105)</td>
<td>419 (86)</td>
<td>374 (97)</td>
<td>395 (173)</td>
<td>0.83</td>
</tr>
<tr>
<td>Hired</td>
<td>23(^c) (70)</td>
<td>190(^b) (58)</td>
<td>645(^c) (65)</td>
<td>1,148(^c) (115)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Contractor</td>
<td>67(^b) (21)</td>
<td>117(^b) (17)</td>
<td>148(^b) (19)</td>
<td>200(^b) (34)</td>
<td>0.004</td>
</tr>
<tr>
<td>Labor efficiency (h/cow)</td>
<td>26.3(^b) (1.4)</td>
<td>17.7(^b) (1.1)</td>
<td>14.3(^c) (1.3)</td>
<td>10.9(^b) (2.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Farmer (h/cow)</td>
<td>17.5(^a) (0.6)</td>
<td>11.6(^b) (0.5)</td>
<td>7.6(^b) (0.6)</td>
<td>4.7(^b) (1.0)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

\(^a\)Different superscripts indicate significant (\(P < 0.05\)) differences between HSC.

\(^1\)HSC 1 = farms with 50–90 cows (19 farms); HSC 2 = farms with 91–139 cows (28 farms); HSC 3 = farms 140–239 cows (22 farms); and HSC 4 = farms ≥ 240 cows (7 farms).

---

### Table 4. Descriptive characteristics of the farmers’ working day across herd size category (HSC)\(^1\) for the study period (February 1 to June 30) and February and March

<table>
<thead>
<tr>
<th>Item</th>
<th>HSC 1</th>
<th>HSC 2</th>
<th>HSC 3</th>
<th>HSC 4</th>
<th>Study average(^2)</th>
<th>Range</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full study period</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start time</td>
<td>0654 h</td>
<td>0650 h</td>
<td>0649 h</td>
<td>0635 h</td>
<td>0649 h</td>
<td>0541–0912 h</td>
<td>0.69</td>
</tr>
<tr>
<td>Finish time</td>
<td>1902 h</td>
<td>1907 h</td>
<td>1856 h</td>
<td>1828 h</td>
<td>1858 h</td>
<td>1702–2136 h</td>
<td>0.37</td>
</tr>
<tr>
<td>Length of working day (h/d)</td>
<td>12.1</td>
<td>12.3</td>
<td>12.1</td>
<td>11.9</td>
<td>12.2</td>
<td>9.8–14.2</td>
<td>0.75</td>
</tr>
<tr>
<td>Nonfarm activity (h/d)</td>
<td>4.2(^a)</td>
<td>3.6(^b)</td>
<td>3.7(^ab)</td>
<td>3.6(^b)</td>
<td>3.8</td>
<td>1.9–5.4</td>
<td>0.07</td>
</tr>
<tr>
<td>Length of working day, excluding nonfarm activity (h/d)</td>
<td>8.0</td>
<td>8.6</td>
<td>8.4</td>
<td>8.3</td>
<td>8.4</td>
<td>5.8–11.1</td>
<td>0.36</td>
</tr>
<tr>
<td><strong>February and March</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start time</td>
<td>0657 h</td>
<td>0656 h</td>
<td>0655 h</td>
<td>0634 h</td>
<td>0654 h</td>
<td>0522–0907 h</td>
<td>0.54</td>
</tr>
<tr>
<td>Finish time</td>
<td>1904 h</td>
<td>1906 h</td>
<td>1906 h</td>
<td>1849 h</td>
<td>1904 h</td>
<td>1715–2226 h</td>
<td>0.91</td>
</tr>
<tr>
<td>Length of working day (h/d)</td>
<td>12.1</td>
<td>12.2</td>
<td>12.2</td>
<td>12.3</td>
<td>12.2</td>
<td>8.5–15.0</td>
<td>0.99</td>
</tr>
<tr>
<td>Nonfarm activity (h/d)</td>
<td>3.9(^c)</td>
<td>3.2(^b)</td>
<td>2.9(^b)</td>
<td>2.9(^b)</td>
<td>3.3</td>
<td>1.8–6.2</td>
<td>0.008</td>
</tr>
<tr>
<td>Length of working day, excluding nonfarm activity (h/d)</td>
<td>8.2(^a)</td>
<td>8.9(^b)</td>
<td>9.3(^b)</td>
<td>9.3(^b)</td>
<td>8.9</td>
<td>5.4–11.8</td>
<td>0.05</td>
</tr>
</tbody>
</table>

\(^a\)Different superscripts indicate significant (\(P < 0.05\)) differences between HSC.

\(^1\)HSC 1 = farms with 50–90 cows (19 farms); HSC 2 = farms with 91–139 cows (28 farms); HSC 3 = farms 140–239 cows (22 farms); and HSC 4 = farms ≥ 240 cows (7 farms).

\(^2\)The average of all farms used in the analysis (n = 76).
h/d); and other enterprises (0.4 h/d). Work completed by contractors accounted for the remaining share of all labor input (0.8 h/d).

Total hours input for each task across HSC is shown in Figure 2. Herd size category 4 spent the most time (6.3 h/d) at milking, whereas HSC 1 (3.9 h/d) and HSC 2 (4.0 h/d) spent the least, and HSC 3 (5.0 h/d) was intermediate (P < 0.001). In terms of milking efficiency (h/cow) for the study period, HSC 1 (8.3 h/cow) was less efficient than all other HSC (HSC 2: 5.3 h/cow, HSC 3: 4.3 h/cow, and HSC 4: 3.3 h/cow; P < 0.001).

Monthly labor input per task is shown in Figure 3. The milking task was the most time-consuming task for each month. Calf care and cow care 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 and it peaked in June. In February and March, when total labor input was highest, repairs and 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 and 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 hours/day in May and June than in the previous months.

**DISCUSSION**

The aim of the study was to quantify labor demand and efficiency on pasture-based dairy farms to gain a greater understanding of the seasonal labor time-use on such farms. Labor efficiency in this study was measured as hours/cow, similar to previous research (O’Donovan et al., 2008; Næss and Bøe, 2011; Deming et al., 2018), which is a key metric to understand labor input as it can allow for comparison and benchmarking of farms of differing scale. Average farm labor efficiency was 18.2 h/cow from February to June for the average herd of 137 cows. Although the February to June period (5 mo) is the busiest time on pasture-based farms (O’Donovan et al., 2008; Deming et al., 2018), this labor efficiency level would seem low relative to some annual studies of farm labor efficiency. Deming et al., (2018) found that average labor efficiency on a subset of Irish farms was 24.1 h/cow for a full year, but this sample of farms were deemed to be highly labor efficient (at that time) and average herd size was larger (187 cows). Alternatively, the study of O’Donovan et al. (2008) included Irish farms with a broader range of efficiency, similar to the current study. The average annual labor efficiency in that study was 46.1 h/cow, which suggests considerable improvement in labor efficiency has taken place on Irish farms over the intervening period. However, in New Zealand, farms have been shown to operate at 15 h/cow per year (Taylor et al., 2009) and the current target for pasture-based dairy systems is 16 h/cow per year (Shalloo and Hanrahan, 2019). Given the wide range in efficiency in the current sample of farms and the fact that many are unable to achieve this target over a 5-mo period, it would appear that a more realistic benchmark for labor efficiency is needed for many farms.

Labor input peaked in February and March with either month being the busiest on 50% of farms. Consequently, farms would benefit from a greater focus on potential labor savings in these months, because any improvements that could be achieved in these 2 mo would aid in suppressing the seasonal nature of labor demand. Examination of how the most labor efficient farmers allocate their time in these 2 mo could offer substantial benefits to farmers highlighting where time-savings could be made. May and June were the months of peak labor input on 45% of farms which, in part, was due to the large input of contractors (mainly for silage harvesting). Also, as these farms were largely single operator, nonessential work in spring may have been postponed until later in the year. Alternatively, there is also a possibility that a proportion of these farmers in HSC 1 and HSC 2 did not have sufficient actual tasks or work to carry out and they were expanding their work to fill the day, as suggested by Deming et

### Table 5. Average total hours of farm labor input per day for each herd size category (HSC)\(^1\) in each month of the study

<table>
<thead>
<tr>
<th>Month</th>
<th>HSC 1</th>
<th>HSC 2</th>
<th>HSC 3</th>
<th>HSC 4</th>
<th>Pooled SE</th>
<th>Study average(^2)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>11.7(^{a})</td>
<td>13.6(^{a})</td>
<td>18.4(^{b})</td>
<td>22.8(^{c})</td>
<td>1.0</td>
<td>15.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>March</td>
<td>12.7(^{a})</td>
<td>13.8(^{a})</td>
<td>18.4(^{b})</td>
<td>22.8(^{b})</td>
<td>1.1</td>
<td>15.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>April</td>
<td>12.2(^{a})</td>
<td>12.9(^{ab})</td>
<td>15.6(^{ac})</td>
<td>18.4(^{a})</td>
<td>1.0</td>
<td>14.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>May</td>
<td>12.4(^{a})</td>
<td>14.7(^{a})</td>
<td>15.3(^{ab})</td>
<td>21.2(^{a})</td>
<td>1.0</td>
<td>14.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>June</td>
<td>11.5(^{a})</td>
<td>13.1(^{ab})</td>
<td>14.4(^{ab})</td>
<td>16.2(^{b})</td>
<td>1.1</td>
<td>13.4</td>
<td>0.06</td>
</tr>
</tbody>
</table>

\(^{a}\)Different superscripts indicate significant (P < 0.05) differences between HSC.

\(^{1}\)HSC 1 = farms with 50–90 cows (19 farms); HSC 2 = farms with 91–139 cows (28 farms); HSC 3 = farms 140–239 cows (22 farms); and HSC 4 = farms ≥ 240 cows (7 farms).

\(^{2}\)The average of all farms used in the analysis (n = 76).
The differences between the minimum and maximum monthly labor input increased as HSC increased, indicating greater peaks and troughs in labor demand on larger farms. Thus, improved springtime productivity to address the peaks and troughs is important, particularly on larger farms, and particularly in light of increased difficulty in attracting labor to work on dairy farms (Eastwood et al., 2018) and the associated cost of additional labor.

As HSC increased there was an associated increase in labor input required, which was supplied by contractors and particularly hired labor, corroborating the findings of O’Donovan et al. (2008) and Deming et al. (2018). However, with regard to HSC 1 and HSC 2, there was no significant difference in total labor input and they were predominantly dependent on the farmers own labor. This may be due to a greater use of labor-saving technologies and practices on HSC 2 farms when compared with HSC 1 (e.g., automatic cluster removers, contract heifer rearing). Larger farms are more likely to mechanize routine tasks as a means of reducing workload (Hostiou and Dedieu, 2012). Furthermore, previous research has indicated that cost effectiveness of many labor-saving technologies is a barrier to adoption for small-scale farms (Borchers and Bewley, 2015), and when labor alternatives are available (i.e., the farmers own labor or family labor in the case of HSC 1 farms) it is possible that farmers are less likely to employ labor-saving techniques. The consistent input of family labor across farms of all herd sizes was similar to Deming et al. (2018). There was larger variability in the family labor input from farm to farm (relative to other labor types) signifying that family labor input is farm specific and mainly depends on the availability of that labor on the farm.

Efficiency (hours/cow) improved with increasing herd size similar to previous studies (O’Donovan et al., 2008; Deming et al., 2018). A positive interaction between increased herd size, and farm management practices, facilities, and work organization has been reported in the studies of Tauer (2001) and Cournut et al. (2018). Also, larger farms are more likely to be the

Figure 1. Breakdown of time spent at each task and contractor input as a proportion of all farm labor input for the study period from February 1 to June 30 (150 d).
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 labor issues on larger farms (Gargiulo et al., 2018). A further contributing factor to the relationship between herd size and efficiency 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 hours/cow) resulting in many smaller farms having difficulty in achieving similar levels of labor efficiency to larger farms. Therefore, setting attainable benchmarks within HSC would benefit farmers to set realistic goals regarding labor efficiency.

Labor input and efficiency varied considerably between herds within different HSC, and this variation decreased with increased HSC, similar to the findings of Næss and Boe (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 not as labor efficient as others in the same HSC could help to achieve improved labor efficiency; this may be approached through examination of their farm facilities, work practices, and work organization.

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 60.0 h/wk for the study period and 63.5 h/wk in February and March. These figures were greater than Deming et al. (2018), who found that farmers worked 56 h/wk in spring (February, March, and April). Deming et al. (2018) specifically selected labor-efficient farmers, and that may explain the difference in results.

Farmer work hours are of considerable importance, with workload being cited as a source of stress by 54% of dairy farmers in Ireland (Brennan et al., 2021). Similarly, working long hours is a significant risk factor regarding health and safety on farms (Osborne et al., 2010). Recognizing 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/wk (Dairy NZ, 2020). A similar benchmark may be useful in other dairy systems 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 labor 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 HSC, there were numerical differences. Farmers in HSC 4 started 19 min earlier than HSC 1 and finished 39 min earlier than HSC 2. The earlier times may have been influenced by the presence of hired labor on larger farms. There was little fluctuation in start and finish times.
times throughout the study, suggesting that farmers worked to a routine and took more time for nonfarm activity during the day when labor 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 h, even though O’Brien et al. (1998) found that milk yield and composition were not affected by changing milking intervals from 12:12 h to 16:8 h. 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 labor efficiency could be made. The proportion of labor input dedicated to milking ranged from 33 to 57% in other pasture-based dairy studies (O’Donovan et al., 2008; Taylor et al., 2009; Deming et al., 2018). Several studies have identified techniques to reduce time spent milking. Having fewer cows per milking unit, and implementing work practices such as once-a-day milking in early lactation have been associated with labor efficient farms (O’Brien et al., 2006; Deming et al., 2018). Similarly, automation technologies, including automatic cluster removers, automatic drafting, and automatic teat spraying, have been shown to improve milking efficiency (Dela Rue et al., 2020). Farms in HSC 1 and HSC 2 spent a similar amount of time at milking, suggesting that milking facilities in HSC 1 may be less labor efficient. As milking was generally a one-person task on these farms, there is less opportunity 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 labor efficiency improvements through technology can be limited in smaller milking facilities compared with larger dairies (Dela Rue et al., 2020).

As HSC increased the amount of time spent at the calf care, cow care, and feeding tasks increased concurrently. This would suggest that techniques to complete these tasks were similar across farms. It would also indicate a smaller scale effect (regarding labor efficiency) for these tasks and that opportunities to improve labor efficiency are similar regardless of herd size. This is likely to be due to the individual specific nature of these tasks (i.e., each cow has to be managed individually when calving and each calf taken care of individually after birth), which would make improvement in labor efficiency more difficult. There were no substantial differences in time spent at the grassland management task, and HSC 4 farmers spent the least amount of time numerically of all HSC at this task. This may have been facilitated by the greater time input by contractors for grassland management on HSC 3 and 4 farms. Contractors usually have more efficient equipment than farmers to complete tasks such as slurry and fertilizer spreading, and they can sometimes reduce or replace the need for additional farm labor or farm machinery (Nye, 2018). These results highlight the labor-saving potential of contractors, which have been shown to not have significant negative effects on farm profitability (Deming et al., 2019). The administration and business task was similar for HSC 1, 2, and 3, but the large rise in time spent at this task for HSC 4 would imply an increase in time spent at business and strategic management where farms have full-time staff, similar to Hadley et al. (2002). In cases of farm expansion, farmers should be aware of this greater level of administration work and its associated time input.

In February and March, calf care and cow care accounted for a substantial proportion of labor input compared with the other months at 21% and 16% of all labor input respectively. Reductions in labor input for these 2 tasks in February and March would greatly aid in suppressing the seasonal nature of labor demand on farms (i.e., if calf care was eliminated, labor input in February and March would be similar to the other months). Therefore, management of these tasks with a focus on minimizing labor requirement is important. Contract heifer rearing (transferring all responsibility for heifer rearing to another person with associated payment) is an increasingly popular practice (Olynk and Wolf, 2010) and putting this arrangement in place before calf weaning represents an option to eliminate a large proportion of the labor input associated with calf care. Several farms included in this study were utilizing this practice or having their heifers contract reared at a later age (Hogan et al., 2022). The labor input associated with the contract rearer is not accounted for in this study. Another possible option for farmers is to employ specialist seasonal labor to oversee the management of these tasks (i.e., a specialist calf rearer) which would allow other farm labor to focus on routine tasks that take place throughout the year. However, this may be difficult as dairy farms already face issues regarding attracting and retaining labor (Eastwood et al., 2018). Other studies have highlighted a selection of time-saving work practices and technologies for these tasks (O’Brien et al., 2006; Gleeson et al., 2008; Deming et al., 2018). Deming et al. (2018) found that early turnout of calves to grass and maintaining calves in group calf pens from birth represented practices associated with the most labor efficient farms. Automatic calf feeders (Sinnott et al., 2021) and once-a-day milk...
feeding (Gleeson et al., 2008) signified other potential labor-saving options for calf care. With regard to cow care, Gleeson et al. (2007) established that restricting silage access until evening feeding reduced the number of nighttime calvings.

Different management strategies and technologies can be employed to reduce labor input requirement on farms once the problem has been identified. Many of these are mentioned above in combination with discussion on labor input of their associated task. The use of smart farming or precision technologies can also be associated with reducing labor input requirement (e.g., automatic milking systems (Shortall et al., 2016), automatic calf feeding (Sinnott et al., 2021) and automated grass measurement (French et al., 2015)). For example, Shortall et al. (2016) showed that automatic milking systems reduced labor input by 36% on a sample of commercial farms. The change in work pattern offered by such technologies, with reduced physical labor and greater emphasis on the management and use of data, can lessen the physically intense nature of the dairy farm workload and reduce labor input (Hostiou et al., 2017). Simultaneously, they could present an opportunity to highlight dairy farming as an innovative career choice for young people. However, such solutions are not appropriate on all farms due to cost and other factors; whereas many farmers wish to reduce labor input, they may not prioritize it over profitability (i.e., farmers in the smaller HSC in the current study). Cost effectiveness (Borchers and Bewley, 2015), trustworthiness (Rose et al., 2016), and perceived relevance and ease of use (Aubert et al., 2012) are among the factors affecting technology adoption on farms. Additionally, personal, social, and cultural circumstances influence farmers’ decision-making behavior regarding technology adoption (McDonald et al., 2014). These technologies will become increasingly prominent on dairy farms in the future, disrupting traditional dairy farm practices. However, it is important that adopting farmers get the necessary support and training in the interpretation of the data and its use in management decision-making to simplify and enable the adoption process.

Reflection on Research Method

This research examined labor 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 3 set days each month. Increased recordings on alternate days each week allowed for the capture of a more diverse range of tasks undertaken on farms; recording on 3 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 recorded in this study 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.

CONCLUSIONS

The results of this study contribute to our understanding of labor use during the busiest time of the year for spring-calving dairy farms in Ireland and point to where greater labor efficiency gains can be made. The results can also be applied to aid seasonal calving systems internationally where labor input peaks during the calving period. Herd size did not impede farms from becoming more labor efficient; however, the large variations observed in labor input and efficiency within HSC underline the requirement for a greater focus on knowledge transfer of methods to achieve improved labor 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, and the many farms that are achieving high levels of labor efficiency and work–life balance in springtime should be emphasized. Finally, this paper highlights hours/cow as a useful measure of labor efficiency to compare farms of different scale. However, this measure gives no indication of farm productivity or profitability so further work should investigate the effect of labor efficiency on such on-farm performance indicators.

ACKNOWLEDGMENTS

This research was supported by Dairy Research Ireland (Dublin, Ireland) and Teagasc’s Walsh Scholarship Scheme (2018–2022; Moorepark, Ireland). The authors acknowledge the farmers who participated in the collection of time-use data and their cooperation. The authors have not stated any conflicts of interest.

REFERENCES


ORCIDS

C. Hogan @ https://orcid.org/0000-0002-7345-245X
J. Kinsella @ https://orcid.org/0000-0002-6556-3555
B. O’Brien @ https://orcid.org/0000-0001-7821-0911
M. Beecher @ https://orcid.org/0000-0001-5161-3489