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## Invited review: Barriers and potential strategies in the implementation of cow-calf contact systems—Insights from dairy cattle farmers and from other livestock production systems

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### ABSTRACT

Cow-calf contact (CCC) systems are of growing scientific interest due to the public concern about early separation of the calf from the dam on dairy cattle farms, which currently occurs soon after calving. Despite the scientifically demonstrated beneficial effects of CCC for both the cow (improving udder health and promoting maternal behaviors) and calf (growth, social learning and reduction of abnormal behaviors), only a small number of dairy cattle farmers practice CCC. Although unpredictable, new animal welfare legislation or best practice guidelines might suggest the adoption of CCC systems in the future. Therefore, the aim of this review is to identify common barriers that prevent farmers from implementing CCC systems and suggest suitable strategies to overcome them. Thus, this review focuses first on identifying barriers that prevent farmers from choosing CCC or transitioning to CCC, considering influencing factors such as region, demographics, and farm characteristics. Second, the review proposes suitable research and knowledge transfer strategies (i.e., communication, dissemination, and education) to address these barriers. For the proposal of research strategies, an overview of mother-offspring management strategies used in other livestock production systems (e.g., beef cattle and dairy sheep) that could potentially be used by dairy cattle farmers to implement CCC systems is provided. The results show that many dairy cattle farmers without CCC experience expressed concerns about the effects of CCC on economic viability, management and staff wellbeing, and animal welfare. However, farmers who practice(d) CCC reported generally positive experiences and did not confirm some of the concerns raised by farmers without CCC experience. This implies that these concerns are knowledge barriers that could be addressed with effective knowledge transfer

strategies. Nevertheless, there were also concerns (e.g., separation distress) that were confirmed by farmers who practice(d) CCC, suggesting that these practical barriers require the exploration of novel strategies. Despite differences in biology or productive values, inspiration could be drawn from mother-offspring management in other livestock systems. For instance, future research on dairy cattle could explore the efficacy of restricted suckling to increase milk yield, as well as the efficacy of keeping calves together with familiar peers to reduce separation distress. Combined with research into economic viability and effective knowledge transfer, insights from other livestock systems could improve the implementation of CCC systems in a way that is sustainable for dairy cattle farmers, beneficial for the welfare of cows and calves, and socially acceptable.

**Key words:** animal welfare, dairy cattle, farmer experience, mother-offspring rearing, cow-calf bond

### INTRODUCTION

In dairy cattle farming, it is standard practice to separate the calf from the dam within 24 h after calving. This practice is believed to improve the economic gain due to increased saleable milk, improved cow reproductive success, minimized disease transmission between dam and calf, improved milking parlor efficiency, and reduced separation distress by separating dam and calf before bonding (Flower and Weary, 2003). However, in the last decades, studies have increasingly shown advantages for both cow and calf when they are kept together, like in cow-calf contact (CCC) systems (Johnsen et al., 2016; Meagher et al., 2019). Cow-calf contact is defined as physical contact between a cow and her own calf, or between a foster cow and her foster calf, allowing behaviors such as licking, sniffing, suckling or nursing, and playing (Sirovnik et al., 2020). Indeed, CCC systems come in many different forms, differing in many aspects, including daily time spent together (full or partial), duration of the contact period (usually ranging from a few

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The list of standard abbreviations for JDS is available at [adsa.org/jds-abbreviations-26](https://adsa.org/jds-abbreviations-26). Nonstandard abbreviations are available in the Notes.

days to the whole preweaning period), and separation mode (abrupt, gradual, or fenceline separation; Sirovnik et al., 2020).

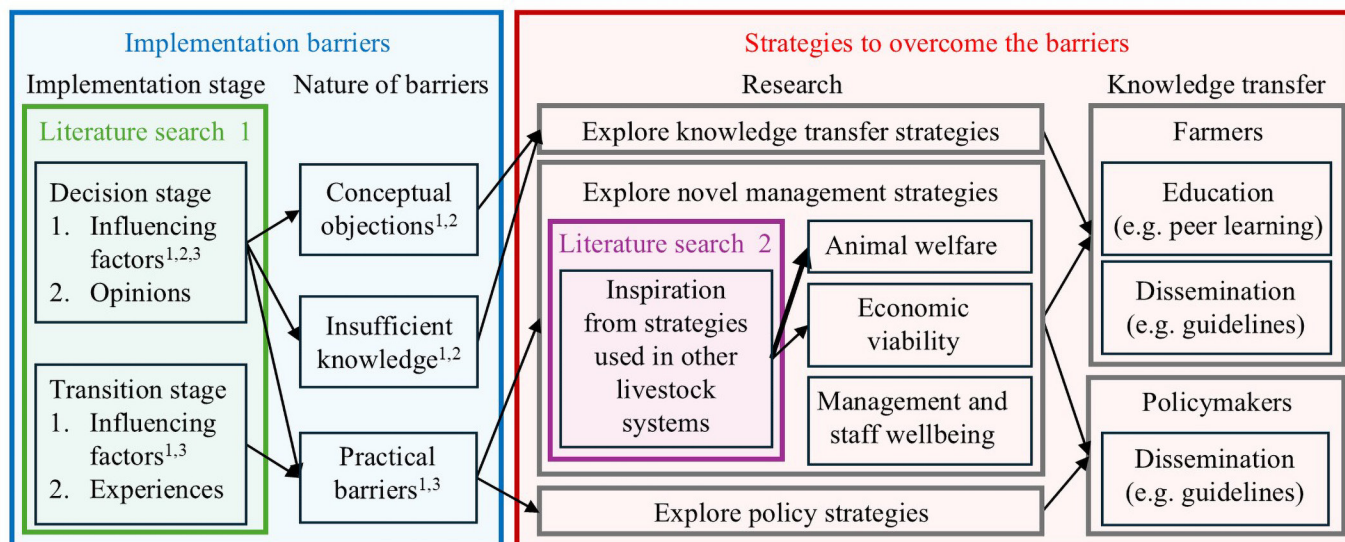
Cow-calf contact was found to benefit social learning in calves, resulting in more socially competent behavior and better integration when introduced to new groups compared with artificially reared calves (Wagner et al., 2012; Magierski et al., 2025). Moreover, dam-reared calves showed fewer stereotypical and abnormal behaviors (Fröberg et al., 2008; Meagher et al., 2019), were less responsive to stressors (Wagner et al., 2015), and had better growth during the suckling period (Krohn et al., 1999) compared with artificially reared calves. Beneficial effects of CCC were also reported for cows, as it has been associated with improved udder health (Krohn, 2001; Johnsen et al., 2016), faster uterus involutions (Jainudeen and Hafez, 2000), and the expression of highly motivated, natural behaviors, such as maternal behavior (Wenker et al., 2020). However, separation was found to be more stressful for both cow and calf the longer the period of contact lasted (Flower and Weary, 2001), suggesting that the positive effect of CCC on animal welfare is not straightforward, particularly if abrupt separation occurs after bonding.

Worldwide, almost no legislative acts exist to regulate the amount of time that cows and calves should be kept together (Whalin et al., 2025). According to stricter animal welfare laws, such as those for organic farming in Denmark and Norway (Vaarst et al., 2020) and the recent European Food Safety Authority opinion on the welfare of calves, it is recommended to keep calves with their dams for a minimum of one day after calving (EFSA Panel on AHAW et al., 2023). In addition, results from many surveys on public opinion in North and South America and Europe show that most citizens are concerned about early cow-calf separation (Placzek et al., 2021). Consequently, they reject systems that apply this practice, including foster rearing and group housing from an early age (Sirovica et al., 2022). Consumers' approval and their consumption choices may drive the dairy sector toward CCC systems, pushing this shift faster than expected (Cook and von Keyserlingk, 2024).

Nevertheless, only a few farmers have adopted CCC, indicating the need for research into the reasons behind this hesitance. Indeed, to the best of the authors' knowledge, only 2 studies have focused on how practicing CCC would economically affect dairy cattle farmers (Knierim et al., 2020; Alvåsen et al., 2023). Recently, several studies have surveyed farmer opinions on CCC systems, as well as the experiences of farmers that already practice CCC. Together, these approaches provide a better understanding of the barriers that farmers encounter at the decision stage (i.e., preventing them from choosing CCC) and at the transition stage (i.e., preventing a smooth transition

to CCC). These studies often focus on different countries and demographics. Because farming and livestock husbandry systems are shaped by the local climate, environmental conditions, traditions, and economic and societal expectations (Whalin et al., 2025), it may be difficult to distinguish from single surveys whether the reported CCC implementation barriers are consistent across demographics or are specific to certain groups of farmers or to certain countries. It is therefore important to combine the findings of these surveys to detect common barriers and identify suitable strategies to overcome them. In the identification of suitable management strategies, it is important to note that the contemporary dairy cattle sector still has little experience with CCC, meaning that many strategies are not yet sufficiently tested on-field. It is therefore very relevant to consider management strategies used in other livestock production systems that have more experience with mother-offspring contact in commercial settings. Although early separation of mothers from their offspring is practiced in many livestock production systems, in general, newborns from beef cattle, buffaloes, small ruminants, and dairy equids spend at least a few days with their dams (but see Appendix Table A1 for more details), underlining that these systems have strategies in place to manage mother-offspring contact. Although differences between the livestock systems in terms of biology and production may sometimes prevent a direct implementation of these strategies in dairy cattle farming, they can serve as inspiration for scientific studies. If these or similar strategies are scientifically proven to work also for dairy cattle, they could be applied to solve problems in the management of dairy cattle CCC systems.

This review aimed to identify common barriers in the implementation of CCC systems by dairy cattle farmers and suggest suitable strategies to tackle them. The first part of this review therefore focuses on improving our understanding of the barriers that prevent dairy cattle farmers from implementing CCC systems. Therefore, this part sets out to provide context to the barriers (considering effects of e.g., region, demographics and farm characteristics) and provides an overview of specific barriers mentioned by farmers, both in the decision stage and transition stage (see Figure 1). The second part of this review focuses on proposing research and knowledge transfer strategies that specifically address the identified implementation barriers. To achieve this, this part explores different management strategies and approaches in mother-offspring management in other livestock production systems. This helps to guide future research on CCC by identifying the issues that are relevant for dairy cattle farmers, thereby contributing to an implementation of CCC that is sustainable and feasible for farmers, welfare-friendly for the animals, and accepted by the public.



**Figure 1.** Overview of the review approach and main outcomes. The blue square shows the first part of the review, which focused on the barriers that obstruct a smooth implementation of CCC systems. The first literature search (green square) served to provide an overview of the barriers and the factors that influence them at the decision and transition stage. Characterization of the nature of the barriers helps to identify suitable research and knowledge transfer strategies directed at farmers or policymakers (or both), which is the focus of the second part of the review (red square). To guide future research, the second literature search (purple square) served to obtain an overview of strategies to manage mother – offspring contact in other livestock systems. These strategies were found to primarily address animal welfare barriers (e.g., separation distress) and, to a lesser extent, economic viability barriers (milk yield).<sup>1–3</sup>Numbers indicate the type of factors that were found to influence the barriers in the decision and transition stage: <sup>1</sup>effects of region (e.g., country, climate, landscape); <sup>2</sup>effects of farmer (e.g., age, gender, societal/educational background); <sup>3</sup>effects of farm characteristics (e.g., herd size, pasture, barn structure, bedding).

## MATERIALS AND METHODS

First, a literature search on dairy cattle farmers' practices, opinions, and experiences regarding CCC was conducted in Scopus (Elsevier B.V.) and Web of Science (Clarivate, Web of Science Core Collection). The keywords (singular) used in the search were dairy, calf, cow, dam, mother, foster, contact, separat\*, wean\*, rear\*, farmer, producer, stakeholder, stock\*; the Booleans used were AND and OR; and the final search query was (dairy) AND (calf OR calves) AND (cow\$ OR dam\$ OR mother\$ OR foster\$) AND (contact OR separat\* OR wean\* OR rear\*) AND (farmer\$ OR producer\$ OR stakeholder\$ OR stock\*). Only peer-reviewed original research papers written in English were included. Papers were included if they focused on at least one of the following 3 topics: (1) management regarding the timing of separation of the calf from the dam, (2) opinions of farmers without CCC experience, or (3) experiences of farmers that practice(d) CCC. If the paper reported a survey on separation practices, it was included if it provided a number or percentage of farms that separated the calf after 24 h or more (meaning surveys that only focused on separation times of less than 24 h were not included). Manual paper screening was performed on the retrieved documents. After removing duplicates, abstracts were read, and if the abstract met one

or more criteria, the full text was retrieved (if available). References in these articles were also checked to search for additional literature. In this case, papers were first selected based on reading the title (applying the previously described criteria), followed by the abstract and the full text.

After reviewing the literature on dairy cattle farmers, practical implementation barriers (i.e., those that were experienced by farmers that practice(d) CCC) were identified and used to guide a second literature search. This search was aimed to find potentially suitable management strategies in literature on mother-offspring rearing in other livestock production systems which are either similar in biology (beef cattle) or in production (goats, sheep, dairy equids and buffaloes). This literature search was carried out using the same databases, targeting reviews that are written in English and peer reviewed. Abstracts were selected if they mentioned one or more of the practical barriers that were reported by dairy cattle farmers (outcome from the first literature search). Full texts were included if they suggested management strategies to overcome these barriers. Depending on the species, the search query was (beef/ sheep/ goat\$/ buffalo OR buffaloes/ donkey\$/ dairy horse\$) AND (calf OR calves/ lamb\$/ kid\$/ calf OR calves/ foal\$/ foal\$) AND (cow\$/ ewe\$/ doe\$/ cow\$/ jenn\*/ mare\$ OR dam\$

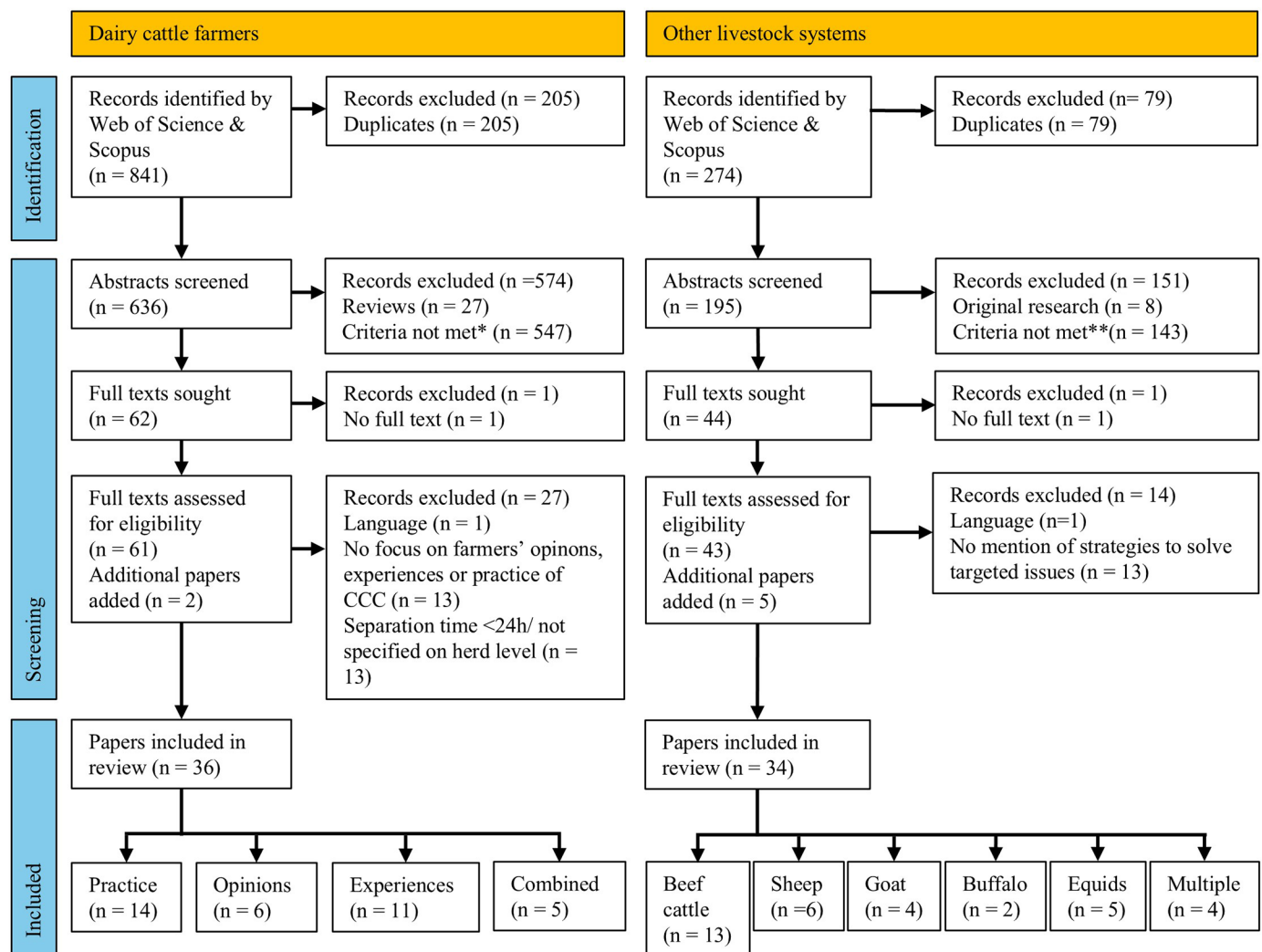
OR mother\$ OR foster\$) AND (contact OR separat\* OR wean\* OR rear\*). The dollar sign in the search query was ignored in Scopus, which automatically included plurals in the search. The date of the final literature search was July 28, 2025.

## RESULTS AND DISCUSSION

### Search Results

The literature search process and the respective numbers of records relative to each search and inclusion and exclusion criteria is represented schematically in a

flowchart (Figure 2). The search on dairy cattle farmers papers resulted in 841 records. Ultimately, 36 articles were included (14 separation practice surveys; 6 studies focusing on the opinions of farmers without CCC experience; 11 studies focusing on the experiences of farmers that practice(d) CCC; and 5 studies that combined these points). The search for reviews on other production systems initially resulted in 222 records. Because only one review on equids was found, the search in these species was extended to original research articles. This resulted in an additional 52 records. Ultimately, 33 papers were included (beef: 13, sheep: 6, goats: 4, buffalo: 2, equids: 5, multiple species: 4).



**Figure 2.** Flowcharts of the literature searches focused on dairy cattle farmers (left) and on other livestock systems (right). \*The criterion for inclusion was a focus on at least one of 3 topics: (1) management regarding the timing of separation, (2) opinions of farmers without CCC experience, or (3) experiences of CCC farmers that practice(d) CCC. \*\*Criterion for inclusion was a focus on strategies that could provide solutions to issues raised by dairy cattle farmers (outcome from the first literature search) in the livestock systems of interest (beef cattle and dairy sheep, goats, buffaloes, horses and donkeys).

### **Factors that Shape the Barriers at the Decision Stage**

The first step in the implementation of a CCC system is choosing to practice it. Several studies provided insight into the factors that influence this decision by documenting the separation practice in different regions (Table 1), whereas others provided insight through surveys and questionnaires on farmers' interest in converting to CCC (Table 2).

**Separation Practices.** Currently, calves are often separated from their dams within the first day after birth in many surveyed countries, particularly in North America and Europe (Table 1), showing that CCC is very rare in these areas. In contrast to Europe and North America, the percentage of farms removing the calf later than one day is slightly higher in countries in South America, Asia, and Africa. One possible partial explanation is the smaller herd sizes in many of these countries, as larger farms tend to separate earlier (Hansen et al., 2023). The cattle breed may also play a role in determining calf rearing methods, because in some indigenous breeds, like Boran and Shami cattle, the presence of the calf helps to stimulate milk let down and increase milk yield (Tegegne et al., 1994; Kaskous et al., 2006). This often leads to the adoption of a system in which the cow and the calf have limited contact for the purpose of suckling (Mandibaya et al., 1999). Only 2 studies directly considered the effects of farmer demography and farm characteristics on separation practices. In a study on Norwegian farmers, it was reported that farmers who practiced CCC were younger, had smaller farms with newer cowsheds, more often had loose housing and automatic milking systems, and more often had the "intention to stay in dairy farming" than farmers that did not practice CCC (Hansen et al., 2023). In contrast, Boaitey (2024) reported that older farmers separated the calf later from the dam (although the survey only focused in detail on the first day after calving). Because only a few studies focused on contact beyond the first days and these studies presented the separation time in different ways, it is difficult to further characterize factors that influence the time of separation. It must also be noted that although contact for longer than one day is officially considered CCC (EFSA Panel on AHAW et al., 2023), most benefits for cow and calf welfare have been recorded in studies in which the contact is maintained for a prolonged period (i.e., at least several weeks; Johnsen et al., 2016; Meagher et al., 2019).

**Farmers' Interest in CCC.** Overall, studies across different countries and geographical areas showed that most farmers object to the use of CCC systems either because they oppose CCC as a concept or because of more specific reasons (which will be discussed in the "Specific Barriers at the Decision and Transition Stage" section). Indeed,

most farmers supported the conventional practice of early separation and did not think that it negatively affects animal welfare, therefore seeing no need to change (Ventura et al., 2013; Pempek et al., 2017; Ritter et al., 2020; Comin et al., 2022; Smith et al., 2025). As suggested by Hansen et al. (2023), the topic seems to evoke strong emotions in many farmers who reported a strong divergence in attitudes toward CCC. This is also evident from the study of Boaitey (2024), where many farmers indicated "none" as their preferred CCC system, even though this option was not on the list. Furthermore, in the study of Neave et al. (2022), most farmers expressed no interest in incentives to implement CCC, which was interpreted as an indication that the systems do not align with the farmers' values regarding animal welfare. Nevertheless, there are indications that financial incentives could be accepted by farmers to convert to CCC systems, even if these incentives would have to be relatively high (Wimmer and Frick, 2022). This may be due to the perceived need to restructure barn facilities to accommodate this practice, which was mentioned as a specific barrier in several surveys (see the "Specific Barriers at the Decision and Transition Stage" section).

Although most farmers had negative attitudes toward CCC, a minority of farmers expressed interest in CCC farming or acknowledged some advantages of CCC for animal health and farmer wellbeing (Neave et al., 2022; Hansen et al., 2023; Steimker et al., 2025). Three studies found that pasture and organic farmers had more positive opinions regarding CCC (Pempek et al., 2017; Hansen et al., 2023; Boaitey, 2024). Hansen et al. (2023) further reported that farmers with an interest in animal welfare and farmers with an intention to stay in dairy farming perceived fewer barriers to implement CCC than farmers who were more production oriented. The roles of other demographics, such as gender and educational and cultural background, have not yet been reported, even though studies on consumer opinions in North America and Europe have shown that they can influence attitudes toward CCC (Ventura et al., 2013; Busch et al., 2017). Moreover, most surveys did not explore the reasons or origins behind the opinions (e.g., through their education, learned from other farmers, or perhaps from experience). Future studies on this topic should therefore aim to explore the opinions of dairy cattle farmers on CCC systems in more detail to better understand why most farmers decide not to implement CCC.

### **Factors that Shape the Barriers at the Transition Stage**

To understand which farm types and characteristics could support CCC farming, we extracted information on the management and structural facilities of the studied commercial CCC farms (where provided) from the re-

**Table 1.** Summary of surveys on the time cows and calves spend together

Country	Sample size (no. farms)	Herd size (no. cows)	Percentage of farms with contact for at least 24 h postpartum	Reference
Kenya	399	Small (not specified)	7.0% <sup>1</sup>	Ajak et al., 2020
Zimbabwe	47	Mean: 6.5	Full contact >3 d: 61.1%/91.3% <sup>2</sup>	Mandibaya et al., 1999
United States	279	Mean: 148	Restricted contact: 100%	Boatley, 2024
United States	621 (including 172 organic)	Majority <100	>1 d: 7.4%	Pempek et al., 2017
United States	466	Mean 219.5 (range 2–12,000)	>1 d: 5% (conventional), 10% (organic)	Sigl et al., 2025
Canada	112	—	>1 d: 3.6%	Trotz-Williams et al., 2008
Canada	115	—	≥2 d: 3.4%	Vasseur et al., 2010
Canada	670	Mean: 90 (range 17–2,800)	>1 d: 5.4%	Medrano-Galarza et al., 2017
Canada	63	Mean: 167 (range: 7–1,200)	>1 d: 7%	Russell et al., 2025
Brazil	179	Median: 201–700	>1 d: 3%	dos Santos and Bittar, 2015
Brazil	242	Mean: 27 (of which 22 were lactating)	>1 d: 9.52%	Hötzel et al., 2014
Uruguay	225	Mean: 134	>2 d: 10%	Schild et al., 2020
India	178 (including 89 organic)	—	>1 d: 28.7%	Maji et al., 2024
Indonesia	100	—	>3 d: 11% (8% foster, 3% dam)	Listiari et al., 2015
Norway	1,038	Mean: 4	>1 d: 62.3%	Hansen et al., 2023
Norway	65	Mean: 36.2 (conventional), 32.5 (CCC)	>2 d: 29.9%	Kjæstad and Simensen, 2001
Germany	42	Mean: 150	Organic: 57.3%, nonorganic: 58.4% <sup>1</sup>	Hayer et al., 2021
			>1 d: 14%	
			>14 d: 2.76%	
			0%	
			>1 d: 7.1% (if born during day)	
			11.9% (if born during night)	

<sup>1</sup>The farms were identified to keep the calves with their dam for a few days (Maji et al., 2024) or to have a suckling system (Ajak et al., 2020), but no specification of the duration of the contact was provided.

<sup>2</sup>The mean was calculated separately for 2 different regions.

**Table 2.** Overview of studies focusing on the opinions of surveyed farmers toward CCC systems

Country	No. of farmers	Indication herd size (no. cows)	Summary of opinions	Reference
United States	279	Range: 50–1,001	Among CCC systems, farmers preferred the foster cow system (34%), followed by restricted suckling (23.7%), half day (10.9%), and free dam-calf (8.6%). 22.8% chose “none.”	Boaitey, 2024
Canada	27	Range: 40–320 (mean: 94)	The main focus was on positive animal welfare. Decrease in saleable milk was mentioned as a barrier to adopt CCC systems.	Brunt et al., 2024
Brazil	158	Majority (82.3%) <200	Only 0.6% of farmers believed that separating cows and calves early led to pain, discomfort or fear.	Comin et al., 2022
Norway	1,038	Mean: 36.2 (conventional), 32.5 (CCC)	15.3% of Norwegian dairy farmers either plan for or want to implement CCC. Poorer financial performance, layout of the cowshed and separation distress were identified as main barriers to adopt CCC.	Hansen et al., 2023
New Zealand	63	Majority: 100–500	Most farmers were reluctant to convert to CCC, owing to practical and economic barriers.	Neave et al., 2022
United States	621	Majority (conventional: 56.2%; organic: 94.4%)	62% of organic farmers and 32% of conventional farmers agreed that separation >2 h is beneficial for the health of the dam. Most farmers agreed that the cow should be able to lick the calf.	Pempek et al., 2017
Canada	25	Range: 40–1,000	Most farmers did not believe the practice of cow-calf separation needed to be addressed.	Ritter et al., 2020
United Kingdom	44	(median 210 calves born per year)	From a list of 13 management practices, farmers ranked immediate cow-calf separation as having the least severe impact on dairy calf welfare.	Smith et al., 2025
Germany	15	Majority: 101–200	Farmers were divided on the issue of CCC. Some supported early separation as a means to minimize separation distress, whereas others recognized the need for contact between cow and calf.	Steimker et al., 2025
Primarily Canada and United States	29	Not specified	62.1% of respondents supported early separation, 27.6% opposed and 10.3% were neutral.	Ventura et al., 2013
Germany	252	Mean $\pm$ SD: 137.81 $\pm$ 186.07	The farmers required a high price premium for rearing calves with the mothers ( $\pm$ €0.106/kg of milk), corresponding to a 30% price increase.	Wimmer and Frick, 2022

ports on the experiences of farmers that practice(d) CCC (Table 3). It must be noted though that none of these studies set out to obtain a representative sample of CCC farms. This means that this overview only provides an indication of the variety of possible CCC systems and is not exhaustive. The sampled farms included both dam-rearing and foster cow systems and adopted a wide range of strategies to manage the duration of contact and mode of separation. Some concerns were raised regarding the compatibility of CCC with housing in cubicles (although reasons for this were not given; Bertelsen and Vaarst, 2023) and on pasture (e.g., due to the need for shelter and fencing; Neave et al., 2022; Johanssen et al., 2023). Nevertheless, Table 3 shows that CCC farming was found to be practiced in a variety of systems, including cubicle housing and pasture. Therefore, these types of housing do not seem to be a limitation per se for CCC (although there may be some exceptions, such as pastures on difficult terrain). In addition, although most CCC farms were small, some surveyed farms had herds of up to 600 cows (Vaarst and Christiansen, 2023). This suggests that under certain circumstances, CCC could also be feasible on farms with larger herds. For instance, results from one study suggested that larger farms are more likely to use foster cows (Hautzinger et al., 2025), but further studies are needed to identify how CCC could be applied on larger farms. Unfortunately, the reviewed studies did not set out to link specific features with the farmer's positive or negative experiences. Therefore, this overview only shows what is possible and does not allow the identification of features that are more (or less) compatible with specific CCC systems. Moreover, several reports also showed that transition to CCC farming is often achieved through small adjustments to the already existing farm structure (e.g., Bertelsen and Vaarst, 2023; Hansen et al., 2023), which explains the strong diversity in the CCC farm management and structure. Although the possibility to convert to CCC with minimal structural adjustments may lower the barriers in the transition process, this diversity makes it difficult to accurately determine the consequences for farmers and animals in these systems. Future research should therefore aim to look for associations between farm features and specific problems across many different CCC systems.

### **Specific Barriers at the Decision and Transition Stage**

Four surveys on the opinions of farmers without CCC experience reported the specific barriers mentioned by these farmers. In this section, these barriers (here referred to as concerns) are compared with the experiences of farmers that practice(d) CCC to differentiate between confirmed or practical barriers, which need to be ad-

ressed by management strategies, and nonconfirmed or knowledge barriers, which need to be addressed by knowledge transfer strategies (Figure 1). As shown in Table 4, most of the concerns of farmers without CCC experience are matched by negative experiences (or problems) of some farmers that practice(d) CCC. Because many of the reviewed studies did not provide exact numbers of farmers reporting a particular experience, it is difficult to give a clear idea of how prevalent a certain experience is. Still, consistent reporting across different surveys may indicate whether an experience is common or not. Moreover, Table 4 provides an overview of the diversity of these experiences. The barriers fall into 3 main categories: economic viability, management and staff wellbeing, and animal welfare.

**Economic Viability.** The economic concerns of farmers without CCC experience are often related to financial performance and the need for restructuring the farm (investment costs). These seem to represent practical barriers because they were matched with negative experiences of some farmers that practice(d) CCC and were sometimes mentioned as reasons to discontinue CCC farming. However, although farmers that practice(d) CCC often mentioned a reduction in saleable milk (although not necessarily supported by economic data) and production, they also often mentioned that this is compensated by improved calf growth and reduced costs for concentrates and drugs (Eriksson et al., 2022; Constancis et al., 2023; Hansen et al., 2023). Alvåsen et al. (2023), based on economic modeling, concluded that CCC leads to a decrease in the contribution margin by 1% to 5.4% compared with conventional rearing. However, this evaluation did not include labor costs and long-term economic consequences. Considering the diversity of CCC systems, it is essential that further economic evaluations of CCC systems are performed. The costs of restructuring were found to vary considerably (e.g., Hautzinger et al., 2025) depending on the CCC system and on the existing farm facilities. The design of a barn for CCC systems should involve careful planning to ensure animal welfare (Geßenhardt et al., 2025). For instance, many dam-rearing systems require a separated area for the cow and calf postpartum to improve the bonding (Jensen et al., 2019). In addition, if the cows and calves are integrated in the herd, a “creep area” where the calves can rest away from the cows is needed (Geßenhardt et al., 2025). However, building a new barn may be relatively inexpensive because farmers reported that the design of CCC systems is usually less complex and that less equipment is needed, as calves do not need to be housed individually and do not need to be fed artificially (Bertelsen and Vaarst, 2023).

**Management and Staff Wellbeing.** Regarding management, some of the concerns of farmers without CCC experience were not confirmed by experiences of

**Table 3.** Overview of the characteristics of CCC farms, as described in the included studies<sup>1</sup>

Country	No. of farms (cows)	Herd size (no. of farms cows)	Housing system <sup>2</sup>	Dam/foster <sup>2,3</sup>	Duration of contact <sup>2</sup>	Separation age	Separation process <sup>2</sup>	Reference
Denmark	12	Range: 55–270	Deep litter: 6, various combinations of deep litter, cubicles, slats and pasture: 6	Dam: 6, foster: 6	Whole day: 8, daytime/nighttime: 3, short time: 1	Mean: 84 d	Abrupt: majority. Some farmers had tried different strategies, but without success	Bertelsen and Vaarst, 2023
France	20	Range: 35–120	At least partially on pasture	Foster	Whole day	12 farms: 4–6 mo, 8 farms: 7–10 mo	Abrupt or gradually	Constancis et al., 2023
Austria, France, Germany, Italy, Poland, Sweden, Switzerland	104	Range: 7–500	Tiestal: 12, cubicles: 44, open pack: 38, other: 10	Dam: 60, foster: 14, hybrid: 30	Whole day: 48, half day: 5, short time: 37, mixed: 14	Median: 12.5 wk (conventional) and 17.0 wk (organic), range: 20–200 d	Abrupt: 71, gradual: 11,	Eriksson et al., 2022
Norway	31	Mean: 32.5	Loose housing: 71%	NS	NS	Mean: 46.5 d	NS	Hansen et al., 2023
Germany	19	Mean: 38.2	Freestall: 17, Pasture: 18	Dam: 4, foster: 5, hybrid: 10	Whole day: 10, half day: 3, short time: 6	Median: 12 wk (start)	Abrupt: 1, gradual: 18	Hautzinger et al., 2025
Norway	12	Mean: 27	Tiestal: 4, freestall: 8	Dam: 11, foster: 1	Whole day: 8, part time: 1,	Mean: 75.4 d	Abrupt: 2, gradual: 6, two-step: 2, fence-line: 2	Johanssen et al., 2023
New Zealand	4	Range: 14–140	Pasture	Dam: 3, foster: 1	NS	≥4 wk	NS	Neave et al., 2022
United Kingdom	5	Range: 11–100	NS	Dam	NS	Range: 4 mo to natural weaning	NS	Thompson, 2023
Denmark	19	NS	9 had switched from tiestalls to loose housing	Dam	NS	≥24 h	NS	Vaarst et al., 2001
Denmark	10	Range: 7–600	Deep litter: 5, pasture: 2, cubicles: 1, deep litter and cubicles/pasture: 2	Dam: 3, foster: 6, hybrid: 1	Whole day: 7,	Mean: approx. 3+ mo, range: 10 wk to 4+ mo	Some farmers had tried gradual weaning	Vaarst and Christiansen, 2023
Denmark, the Netherlands, France, Norway	73	NS	NS	Dam, foster and hybrid	Whole day contact, part time contact, and cow/calf driven contact	NS	Abrupt, gradual, two-step and fence-line	Vaarst et al., 2020
Norway and Sweden	6	Range: 20–330	Tiestalls and loose housing: 2 farms had outdoor access	Dam: 5, foster: 1	NS	Mean: 23.8 d	NS	Vetouli et al., 2012
The Netherlands	2	Mean: 62.5	Deep litter: 1, cubicles: 1	Foster: 1, hybrid: 1	NS	NS	Gradual	Wagenaar and Langhout, 2007

<sup>1</sup>Approx. = approximately; NS = not specified.<sup>2</sup>Numbers in these columns refer to the number of farms.<sup>3</sup>Hybrid is a combination of dam and foster rearing, meaning the calves first stay for a certain period with the dam and are then transferred to a foster cow.

**Table 4.** Overview of the concerns expressed by surveyed farmers without CCC experience matched with the positive, negative and neutral (or other) experiences of farmers that practice(d) CCC,<sup>1</sup> and strategies used by farmers that practice(d) CCC to solve experienced problems<sup>2</sup>

Topic	Experiences of farmers that practice(d) CCC					Reason to discontinue CCC
	Concerns of farmers without CCC experience	Positive	Other or neutral	Negative	Strategies	
Economic viability	Financial performance (Neave et al., 2022; Hansen et al., 2023; Brunt et al., 2024)	Fewer costs for staff (Neave et al., 2022; Bertelsen and Vaarst, 2023), drugs (Bertelsen and Vaarst, 2023), concentrates (Constancis et al., 2023) and veterinary costs (Hautzinger et al., 2025)	No change in saleable milk (Vaarst and Christiansen, 2023)	Less saleable milk (Vaarst et al., 2020; Neave et al., 2022; Bertelsen and Vaarst, 2023; Hansen et al., 2023; Johanssen et al., 2023; Thompson, 2023; Hautzinger et al., 2025)	Selling milk on-farm/as niche product (Bertelsen and Vaarst, 2023; Thompson, 2023) Foster cow system (Brunt et al., 2024)	Less saleable milk (Bertelsen and Vaarst, 2023; Hansen et al., 2023)
		Using milk from undesirable milking cows (foster cow system; Bertelsen and Vaarst, 2023; Constancis et al., 2023)	No change in fertility (Eriksson et al., 2022; Hansen et al., 2023)	Poorer milk let down (Wagenaar and Langhout, 2007; Vaarst et al., 2020; Bertelsen and Vaarst, 2023; Johanssen et al., 2023; Vaarst and Christiansen, 2023; Hautzinger et al., 2025)	Removal of the calf some time before or after milking (Wagenaar and Langhout, 2007; Johanssen et al., 2023; Vaarst and Christiansen, 2023) Calf suckling during milking (Johanssen et al., 2023)	Reduced milk quality (Hansen et al., 2023)
		Faster calf growth (Wagenaar and Langhout, 2007; Eriksson et al., 2022; Hansen et al., 2023; Brunt et al., 2024; Constancis et al., 2023; Hautzinger et al., 2025)		Cannot cull high SCC dams (Bertelsen and Vaarst, 2023)		
		Lower age at first calving (Constancis et al., 2023)		Limited market for sale of older male dairy calves (Hautzinger et al., 2025)		
Barn restructuring needed (Pennek et al., 2017; Neave et al., 2022; Hansen et al., 2023)	Less equipment needed (Bertelsen and Vaarst, 2023)	No or little restructuring needed (Hansen et al., 2023)	Restructuring needed (Vaarst et al., 2020; Eriksson et al., 2022; Neave et al., 2022; Johanssen et al., 2023; Hautzinger et al., 2025)	Seasonal calving (on pasture; Bertelsen and Vaarst, 2023)	Inadequate barn structure (Hansen et al., 2023)	

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**Table 4 (Continued).** Overview of the concerns expressed by surveyed farmers without CCC experience matched with the positive, negative and neutral (or other) experiences of farmers that practice(d) CCC,<sup>1</sup> and strategies used by farmers that practice(d) CCC to solve experienced problems<sup>2</sup>

Topic	Experiences of farmers that practice(d) CCC					
	Concerns of farmers without CCC experience	Positive	Other or neutral	Negative	Strategies	Reason to discontinue CCC
Management and staff wellbeing	Workload (Neave et al., 2022; Hansen et al., 2023)	Reduced workload (Neave et al., 2022; Constançis et al., 2023; Hansen et al., 2023; Brunt et al., 2024; Hautzinger et al., 2025) Increased work flexibility (Bertelsen and Vaarst, 2023; Hansen et al., 2023; Johanssen et al., 2023)	Similar workload (Eriksson et al., 2022; Johanssen et al., 2023; Vaarst and Christiansen, 2023) Different type of work (Vaarst et al., 2020; Bertelsen and Vaarst, 2023; Constançis et al., 2023; Johanssen et al., 2023)	Training/habituation period needed (Vaarst and Christiansen, 2023)		Increased workload (Hansen et al., 2023)
Herd management (Neave et al., 2022)	No separate calf management (Neave et al., 2022) Calm herds (Vaarst et al., 2020) Better heifer integration in dairy herd (Wagenaar and Langhout, 2007; Constançis et al., 2023) Alternative use of high SCC cows (foster cow systems; Constançis et al., 2023)					
Milking management (Neave et al., 2022)				Difficult milking routine when calves join in the parlor (Neave et al., 2022) More “wild” calves (some farmers; Vaarst et al., 2020)	Frequent handling of calves (Vaarst et al., 2020; Bertelsen and Vaarst, 2023; Constançis et al., 2023; Johanssen et al., 2023; Vaarst and Christiansen, 2023; Hautzinger et al., 2025)	
“Wild” calves (Neave et al., 2022)		Calves not “wild” (Wagenaar and Langhout, 2007; Neave et al., 2022; Bertelsen and Vaarst, 2023; Constançis et al., 2023; Johanssen et al., 2023)				
Teaching calves to feed (Neave et al., 2022)	Calves learned to feed solid feeds from cow (Wagenaar and Langhout, 2007; Johanssen et al., 2023; Vaarst et al., 2020; Bertelsen and Vaarst, 2023)			Difficult to teach calves to drink from bottle (Vaarst et al., 2020; Johanssen et al., 2023)		
Work safety (Neave et al., 2022)	Increased job satisfaction (Vaarst et al., 2020; Bertelsen and Vaarst, 2023; Vaarst and Christiansen, 2023; Hansen et al., 2023)	No change in work safety (Neave et al., 2022)		Some dams aggressive toward people (Johanssen et al., 2023)		Reduced work safety (Hansen et al., 2023)
Lack of knowledge (Hansen et al., 2023)				Lack of knowledge or CCC systems complicated (Eriksson et al., 2022) Less control (Vaarst et al., 2020)		

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**Table 4 (Continued).** Overview of the concerns expressed by surveyed farmers without CCC experience matched with the positive, negative and neutral (or other) experiences of farmers that practice(d) CCC,<sup>1</sup> and strategies used by farmers that practice(d) CCC to solve experienced problems<sup>2</sup>

Experiences of farmers that practice(d) CCC						
Topic	Concerns of farmers without CCC experience	Positive	Other or neutral	Negative	Strategies	Reason to discontinue CCC
Calf welfare	Cow maternal abilities (Neave et al., 2022)	Cows seen as good mothers (Vaarst et al., 2020; Neave et al., 2022; Johanssen et al., 2023)		Few cows were not good mothers/rejected calf (Wagenaar and Langhout, 2007; Constancis et al., 2023)	Separated bonding pen (Wagenaar and Langhout, 2007; Constancis et al., 2023; Johanssen et al., 2023) Blocking the cow (Constancis et al., 2023) Selection cows based on good maternal abilities (Constancis et al., 2023)	—
		Calves benefit from care of cows/ learning from cows (Vaarst et al., 2020; Bertelsen and Vaarst, 2023; Constancis et al., 2023; Johanssen et al., 2023; Vaarst and Christiansen, 2023; Hautzinger et al., 2025)	Colostrum intake of no concern (Neave et al., 2022)	Insufficient colostrum intake (Vaarst et al., 2001)	(Additional) colostrum feeding (Eriksson et al., 2022; Johanssen et al., 2023) Monitoring colostrum quality and intake (Johanssen et al., 2023) Putting covers on calves (Neave et al., 2022) Avoiding winter or spring calving (Neave et al., 2022) Part-time separation when cows are on pasture (Bertelsen and Vaarst, 2023)	—
		Keeping calves on pasture reduced workload, risk of infection, and injuries (Johanssen et al., 2023)	—	Protection needed on pasture (Neave et al., 2022; Vaarst and Christiansen, 2023)		—
	Shelter on pasture (Neave et al., 2022)	Improved calf health (Wagenaar and Langhout, 2007; Vetouli et al., 2012; Vaarst et al., 2020; Hansen et al., 2023; Brunt et al., 2024; Constancis et al., 2023)	—	Pasture not suitable for calves (e.g., long distances to walk; Bertelsen and Vaarst, 2023; Johanssen et al., 2023) More disease incidences (Vaarst and Christiansen, 2023)		Reduced health of calf/cow (Hansen et al., 2023)
	Not mentioned concerns	Less stereotypical behavior (Vaarst et al., 2020; Constancis et al., 2023)	No increase in injuries (Wagenaar and Langhout, 2007)	Monitoring calf health more challenging (Hautzinger et al., 2025) Risks of injuries to calves (Vaarst et al., 2020)	Strict hygiene regulations (Vaarst and Christiansen, 2023) Monitoring and early intervention (Vaarst and Christiansen, 2023)	

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**Table 4 (Continued).** Overview of the concerns expressed by surveyed farmers without CCC experience matched with the positive, negative and neutral (or other) experiences of farmers that practice(d) CCC,<sup>1</sup> and strategies used by farmers that practice(d) CCC to solve experienced problems<sup>2</sup>

Topic	Experiences of farmers that practice(d) CCC					Reason to discontinue CCC
	Concerns of farmers without CCC experience	Positive	Other or neutral	Negative	Strategies	
Cow welfare	Udder injuries and mastitis (Neave et al., 2022)	Same/better udder health (Vétouli et al., 2012; Eriksson et al., 2022; Neave et al., 2022; Hautzinger et al., 2025) Fewer incidences of milk fever and retained placenta (Vaarst et al., 2020)	—	Poor body condition of foster cows (Constancis et al., 2023)	—	—
Cow-calf separation	Separation distress (Neave et al., 2022)	—	Separation distress considered acceptable (Bertelsen and Vaarst, 2023)	Separation distress (Wagenaar and Langhout, 2007; Vétouli et al., 2012; Vaarst et al., 2020; Eriksson et al., 2022; Hansen et al., 2023; Johanssen et al., 2023; Hautzinger et al., 2025)	Gradual weaning (Eriksson et al., 2022; Hautzinger et al., 2025) 2-step weaning (Wagenaar and Langhout, 2007; Eriksson et al., 2022; Constancis et al., 2023) Separating several cow-calf pairs simultaneously (Johanssen et al., 2023) Foster cow system (Wagenaar and Langhout, 2007) Herbal or pharmacological treatments (Eriksson et al., 2022) Distract with attractive feed (Eriksson et al., 2022) Pairing foster cows with fresh calves (Eriksson et al., 2022) Keeping some (foster) cows with calves (Constancis et al., 2023)	—
			Later separation delays stress (Vaarst et al., 2020)	Milking difficulties after separation (Eriksson et al., 2022) Reduced growth or weight loss in calves after separation (Vaarst et al., 2020; Eriksson et al., 2022)		

<sup>1</sup>The farmers in the study of Vaarst et al. (2001) prolonged the separation age to >24 h as part of a transition to organic farming. Therefore, their experiences were only included when directly referring to CCC.

<sup>2</sup>The last column lists the reasons of farmers for discontinuing CCC. Entries are either based on the majority of farmers cited in a study or, if the majority was not clearly indicated, any statement by any farmer that was mentioned in the report.

farmers that practice(d) CCC. For instance, farmers that practice(d) CCC mentioned that regular handling could easily prevent the calves from becoming difficult to handle (Vaarst et al., 2020; Bertelsen and Vaarst, 2023; Constancis et al., 2023). In addition, most farmers that practice(d) CCC experienced no difference in the workload amount, but did experience a change from acting to observing (Bertelsen and Vaarst, 2023; Constancis et al., 2023). Several also noticed an increase in work flexibility because the calves do not need to be fed at fixed times (Hansen et al., 2023; Johanssen et al., 2023). However, a minority of farmers mentioned that they discontinued CCC due to an increased workload (no further specifications for these decisions were provided; Hansen et al., 2023), meaning that this aspect still needs attention. Similarly, efforts should be made to ensure work safety, even if cow aggression was only mentioned by some CCC farmers in one study (Johanssen et al., 2023). Cows may show aggression toward humans to protect their calves (Hoppe et al., 2008). Such behavior may be reduced by adopting strategies already suggested for beef cattle farming, such as selective breeding, temperament testing, and training of the stockpeople to improve handling (Costa et al., 2021). Other negative experiences seem to depend on many factors, such as farm type and management strategy. For instance, the pastures in some milder climates and in less hostile landscapes may be more suited for managing CCC compared with forest and mountain pastures (Johanssen et al., 2023). Difficulties in teaching calves how to eat solid feed may only occur if they are separated before weaning. Instead, if calves are introduced to solid feed when they are together with their mothers, the transition from milk may be even easier, as the calf is able to learn how to eat from the cow (Vaarst et al., 2020; Bertelsen and Vaarst, 2023). Milk management may be difficult on farms with a milking parlor where cows are separated from their calf for longer periods, as compared with farms with automatic milking systems. In addition, “more complicated farm management” mostly depends on how the calves are housed (with the herd or in a creep area) and whether there is a regular separation of cows and calves (e.g., in intermittent contact systems). Overall, it seems that many of the concerns of farmers without CCC experience relating to increased labor and management complexity are knowledge barriers rather than practical barriers. Therefore, these could be addressed by knowledge transfer strategies. However, because most reports are based on farmers’ statements, efforts should be made to quantify the labor involved in managing different CCC systems. It is also important to note that almost all studies reported that CCC farmers mentioned job satisfaction and farmer wellbeing as major positive experiences in CCC farming, suggesting that

overall, the management of CCC systems can be rewarding.

**Animal Welfare.** The concerns relating to animal welfare were mainly focused on the calf, whereas the welfare of the cows was less considered (Vaarst et al., 2020). Still, some studies reported improved udder health (e.g., Vetouli et al., 2012; Eriksson et al., 2022; Neave et al., 2022) and reduced incidences of milk fever and retained placenta (Vaarst et al., 2020). In contrast, another report mentioned poorer body condition of foster cows (Constancis et al., 2023). Regarding calf welfare, the positive accounts seem to outnumber the negative ones. Indeed, the concern that dairy cows are not good mothers seems largely unfounded. However, the bonding process, especially with foster cows, was mentioned as requiring special attention, and it seems important that the cow and calf have sufficient time together before joining the rest of the group (Constancis et al., 2023; Johanssen et al., 2023). The concerns relating to colostrum intake were not always confirmed, and it seems that these concerns could be addressed through careful monitoring and good hygiene management (Vaarst et al., 2001; Johanssen et al., 2023). Because immunoglobulin transfer across the gut epithelium begins to decline rapidly 12 h after birth (Weaver et al., 2000), it is important that farmers observe whether calves suckle the dam in time. Although farmers that practice(d) CCC often reported improved calf health, disease prevention in CCC systems likely requires the use of different strategies from those used in conventional systems. For instance, several farmers that practice(d) CCC mentioned that they spend more time monitoring for signs of good health and behavior rather than intervening in the management of cow and calf health (Vaarst et al., 2020; Vaarst and Christiansen, 2023). Some farmers reported that the monitoring of calf health is challenging (Hautzinger et al., 2025). Therefore, although many barriers relating to cow and calf health seem to be knowledge barriers, research may still be needed to improve monitoring strategies.

Separation distress is one concern that was clearly confirmed by the experiences of farmers that practice(d) CCC. The bond between a dam and her calf is established as early as 5 min after birth (Hudson and Mullord, 1977) and is reinforced through the act of suckling, which induces oxytocin release (Uvnäs-Moberg, 1998), although bonds can also be formed in the absence of nursing (Johnsen et al., 2015). As a result, separation is particularly stressful for both dam and calf (Flower and Weary, 2003). The reports also mentioned that farmers have tried many strategies to reduce this stress. These strategies often aim to achieve a gradual reduction of contact before separation (Eriksson et al., 2022; Johanssen et al., 2023; Hautzinger et al., 2025) or focus on the prevention of the

simultaneous occurrence of separation and weaning distress, e.g., by allowing fence-line contact after separation or by artificially feeding the calf milk after separation (Eriksson et al., 2022; Johanssen et al., 2023). Some of these strategies have also been found to reduce separation distress in experimental studies (Wenker et al., 2022; Bertelsen et al., 2023). Still, many surveyed farmers did not find the strategies that they tried effective in reducing separation distress (Eriksson et al., 2022; Bertelsen and Vaarst, 2023). Although some farmers considered separation distress to be outbalanced by the positive welfare aspects offered by CCC (Bertelsen and Vaarst, 2023; Brunt et al., 2024), identifying effective separation strategies seems important for improving animal welfare and for a larger acceptance of CCC by dairy cattle farmers.

**Limitations.** Because the provided overview in Table 4 is based on a few studies on farmers' opinions and experiences, which were also primarily performed in European and North American countries, the opinions and experiences may be biased by the farming systems used in these countries and the cultural and socio-economical background of the surveyed farmers. Further research is therefore required to refine this table and to complete it with insights from farmers from other continents. Furthermore, as CCC is practiced by relatively few farmers, most of the reviewed studies had small and heterogeneous samples, constraining their capacity to assess the effectiveness of management strategies across different contexts. This makes it difficult to draw clear conclusions about the prevalence of certain problems, as well as to identify associations with certain CCC systems, barn structure, or management decisions. Nevertheless, these questions need to be addressed to improve the management of CCC systems.

### Strategies to Overcome Implementation Barriers

With the rising public pressure to implement CCC systems, it is important that these systems represent a viable option for dairy cattle farmers. From the previous sections, it becomes clear that most farmers without CCC experience do not yet see it as a feasible practice. In addition, although most farmers that practice(d) CCC are positive about their experience, many face problems in managing CCC. Some have even discontinued the practice or are considering discontinuing it because of these problems. In the first part of the review, we identified different types of barriers that can be encountered at the decision or transition stage (Figure 1). In this second part, we propose suitable research and knowledge transfer strategies to overcome these barriers.

### Research Directions

As shown in Figure 1, different barriers call for different strategies to overcome them. Many barriers were found to be of a practical nature (i.e., they were experienced by farmers that practice(d) CCC). In this case, practices in mother-offspring management in different livestock systems can serve as inspiration. Management strategies that could potentially be adapted to dairy cattle farming to overcome the identified practical barriers (see the "Specific Barriers at the Decision and Transition Stage" section) are shown in Table 5. The research strategies will be discussed according to the 3 areas of concern (economic viability, management and staff wellbeing, and animal welfare).

**Research to Improve Economic Viability.** In the literature on other livestock systems, only strategies to increase milk yield were found. To prevent reduced saleable milk, literature on dairy sheep and goats mainly suggests restricted suckling (and contact; Lu and Potchoiba, 1988; Sevi et al., 2009; Freitas-de-Melo et al., 2022), as this was found not to reduce milk yield compared with artificial rearing (McKusick et al., 2001). Restricted suckling is also practiced in dairy equid farming, where the foals are removed a few hours before milking to increase milk yield (Alabiso et al., 2009; D'Alessandro and Martemucci, 2012; De Palo et al., 2022). In donkeys, separation intervals of 2 h were found to have little effect on the welfare of jennies and foals (de Souza Farias et al., 2021), but very little research has been done on this so far. Considering that restricted suckling is also practiced with some dairy cattle breeds (Mandibaya et al., 1999; Orihuela and Galina, 2021; Eriksson et al., 2022), this strategy may also work for dairy cattle farming. However, more research is needed to determine if this may be successfully applied to high-yielding breeds. Because economic viability depends on more than only milk yield, there is an urgent need to study how CCC affects financial performance (see Knierim et al., 2020 and Alvåsen et al., 2023). Studies on the practical implications of converting to CCC systems, such as barn restructuring, are also needed.

**Research to Improve Management and Staff Wellbeing.** We found no suggestions in the literature on other livestock systems. Indeed, the impact of CCC on farm management is best understood if it is compared with management in farms with artificial rearing. Therefore, this is better performed by focusing on dairy cattle, where these 2 different systems coexist.

**Research to Improve Animal Welfare.** Many strategies in other livestock systems focus on offspring health and survival, often through improving colostrum intake and maternal care. These strategies can be grouped into nutritional strategies (to improve dam health), monitor-

**Table 5.** Suggested mitigation strategies from literature on livestock production systems other than dairy cattle to tackle the practical barriers that were reported by dairy cattle farmers (see Table 4); only barriers for which strategies were found are presented here

Barriers reported by dairy cattle farmers relating to CCC	Suggested mitigation strategies	Livestock system
Reduced milk yield	Restricted suckling	Goats (Sevi et al., 2009), equids (Alabiso et al., 2009; D'Alessandro and Martemucci, 2012; Dai et al., 2017; de Souza Farias et al., 2021; De Palo et al., 2022), Sheep (Sevi et al., 2009; Freitas-de-Melo et al., 2022)
Offspring survival and health (general)	Adequate nutrition for dam Dietary supplementation Separate maternity site Prevention of complications during birth Monitoring of offspring health Limiting exposure to older and sick peers Dispersion of livestock to maximize hygiene Ensuring good body condition of dam before parturition Adequate nutrition before parturition	Beef cattle (Nevard et al., 2022), goats (Idamokoro et al., 2017) Beef cattle (Burns et al., 2010; Sanguinetti et al., 2025) Beef cattle (Larson and Tyler, 2005; Lorenz et al., 2011) Beef cattle (Larson and Tyler, 2005; Lorenz et al., 2011) Beef cattle (Lorenz et al., 2011) Beef cattle (Sanguinetti et al., 2025; Larson and Tyler, 2005) Beef cattle (Larson and Tyler, 2005) Beef cattle (Larson and Tyler, 2005) Beef cattle (Winton et al., 2024), sheep (Schmoelzl and Cowley, 2016) Beef cattle (Larson and Tyler, 2005; McGee and Earley, 2019) Beef cattle (Sanguinetti et al., 2025) Beef cattle (Sanguinetti et al., 2025; McGee and Earley, 2019)
Colostrum intake	Prevention of complications during birth Checking udder fullness Assisted suckling in case of assisted parturition or if offspring does not suckle	Beef cattle (McGee and Earley, 2019), buffalo (Orihuela et al., 2020) Beef cattle (Nevard et al., 2022), goats (Idamokoro et al., 2017; Robertson et al., 2020), sheep (Schmoelzl and Cowley, 2016; Orihuela et al., 2021) Goats (Idamokoro et al., 2017; Robertson et al., 2020) Buffalo (Orihuela et al., 2021), sheep (Orihuela et al., 2021) Sheep (Haughey, 1991) Sheep (Haughey, 1991) Sheep (Orihuela, 2021) Sheep (Haughey, 1991; Enriquez et al., 2011)
Maternal care	Artificial colostrum administration Selecting dams for mothering abilities	Beef cattle (McGee and Earley, 2019), buffalo (Orihuela et al., 2020) Beef cattle (Nevard et al., 2022), goats (Idamokoro et al., 2017; Robertson et al., 2020), sheep (Schmoelzl and Cowley, 2016; Orihuela et al., 2021)
Shelter on pasture	Adequate nutrition for dam Prevention of complications during birth Minimal human interference around parturition time Low stock densities around time of parturition Placement with surrogate mother Provision of shelter (mainly through retaining trees and shrubs)	Goats (Idamokoro et al., 2017; Robertson et al., 2020) Buffalo (Orihuela et al., 2021), sheep (Orihuela et al., 2021) Sheep (Haughey, 1991) Sheep (Haughey, 1991) Sheep (Orihuela, 2021) Sheep (Haughey, 1991; Enriquez et al., 2011)

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**Table 5 (Continued).** Suggested mitigation strategies from literature on livestock production systems other than dairy cattle to tackle the practical barriers that were reported by dairy cattle farmers (see Table 4); only barriers for which strategies were found are presented here

Barriers reported by dairy cattle farmers relating to CCC	Suggested mitigation strategies	Livestock system
Stress at separation/weaning	Habituation to new pen or peers before separation Creep feeding (providing solid feed before weaning)	Beef cattle (Masters et al., 2023), goats (Datt et al., 2023) Beef cattle (Winton et al., 2024; Orihuela, 2021; Rasby, 2007; Lynch et al., 2019; Orihuela and Galina, 2019), goats (Datt et al., 2023), sheep (Freitas-de-Melo et al., 2022)
	Weaning based on body weight Dam controlled contact 2-step weaning: using anti-suckling device or fenceline to maintain contact after weaning	Goats (Lu and Pochoiba, 1988) Beef cattle (Weary et al., 2008) Beef cattle (Winton et al., 2024; Orihuela, 2021; Masters et al., 2023; Rasby, 2007; Lynch et al., 2019; Orihuela and Galina, 2019; Newberry and Swanson, 2008; Whalin et al., 2021), equids (Newberry and Swanson, 2008), sheep (Freitas-de-Melo et al., 2022; Orihuela, 2021; Napolitano et al., 2008; Mora-Medina et al., 2015) <sup>1</sup>
	Gradual increase of hours of separation	Beef cattle (Weary et al., 2008), buffalo (Datt et al., 2023; de la Cruz-Cruz et al., 2019), goats (Datt et al., 2023) <sup>1</sup>
	Inducing estrous on day of separation Grouping after separation based on body size Keeping with familiar peers after separation	Sheep (Freitas-de-Melo et al., 2022; Orihuela, 2021) Beef cattle (Orihuela, 2021)
	Keeping in same environment after separation	Beef cattle (Orihuela, 2021; Orihuela and Galina, 2019), sheep (Sevi et al., 2009; Freitas-de-Melo et al., 2022; Newberry and Swanson, 2008; Mora-Medina et al., 2015)
	Keeping with unrelated adult(s) after separation	Beef cattle (Orihuela, 2021; Rasby, 2007; Lynch et al., 2019; Orihuela and Galina, 2019), sheep (Freitas-de-Melo et al., 2022)
	Positive handling/presence of familiar stockperson	Beef cattle (Rasby, 2007), sheep (Sevi et al., 2009; Freitas-de-Melo et al., 2022; Orihuela, 2021; Napolitano et al., 2008)
	Providing artificial teat after separation Pharmacological treatments Dietary supplementation	Equids (Newberry and Swanson, 2008), goats (Sevi et al., 2009), sheep (Freitas-de-Melo et al., 2022; Orihuela, 2021; Newberry and Swanson, 2008) Beef cattle (Newberry and Swanson, 2008) Sheep (Freitas-de-Melo et al., 2022) Sheep (Freitas-de-Melo et al., 2022; Napolitano et al., 2008)

<sup>1</sup>The references discuss this strategy critically.

ing and (if necessary) assistance around parturition (to ensure dam and calf health), and colostrum intake and sanitation strategies (to limit infectious diseases). The nutritional strategies mainly focus on adequate nutrition of the dam (especially during late gestation) to ensure sufficient milk production (Idamokoro et al., 2017; Nevard et al., 2023), good quality colostrum (Winton et al., 2024), and good maternal behavior (Schmoelzl and Cowley, 2016; Orihuela et al., 2021). Monitoring and assistance strategies are aimed to prevent complications during birth, which can affect the ability of the cow or calf to stand up in time for suckling colostrum and to develop a bond (Larson and Tyler, 2005; McGee and Earley, 2019; Orihuela et al., 2021). Other strategies focus on postpartum monitoring and intervention, especially regarding colostrum intake. However, in buffaloes, artificially providing colostrum was not found to increase immunoglobulin levels (Bharti et al., 2015). In addition, human intervention around the time of parturition could disrupt the bonding process (Haughey, 1991). Farmers should therefore carefully consider when intervention is required or not. Finally, the use of separate (clean) maternity sites, avoiding contact with older peers and the dispersal of animals are all suggested as measures to avoid the spread of infectious diseases in beef cattle (Larson and Tyler, 2005; Lorenz et al., 2011), although a meta-analysis on beef cattle confirmed the efficacy of only one of these measures (i.e., short calving seasons to avoid contact with older peers; Sanguinetti et al., 2023). Because health was not found to be reduced in CCC systems (Beaver et al., 2019), most CCC farmers may already use similar strategies or have found other strategies to prevent health issues. Nevertheless, because a few farmers that practice(d) CCC reported health issues, further research should be done to improve the health of cows and calves in CCC systems. Such research should explore the applicability of the above-mentioned management strategies for dairy cattle farming.

As with dairy cattle farmers that practice(d) CCC, farmers in the reviewed livestock systems encounter distress due to separation of dam and offspring, even though the involved procedures may be different. For instance, in beef cattle farming, separation from the dam often occurs simultaneously with weaning (change from milk to solid feed; Weary et al., 2008). Accordingly, many suggested strategies to reduce stress for beef cattle, as well as for dairy sheep and equids, focus on separating these stressful events, such as by using nose flaps or fence lines (also referred to as 2-step weaning). Another often-mentioned strategy is gradually increasing the time that the dam and offspring are separated (Orgeur et al., 1998; Schichowski et al., 2008; de la Cruz-Cruz et al., 2019). However, in goats and sheep, both the gradual and 2-step weaning strategies were sometimes found to increase the stress

response (Napolitano, 2003; Sevi et al., 2003), possibly depending on the age at which they begin (Freitas-de-Melo et al., 2022). Moreover, with gradual weaning, there may be a risk of inducing a permanent increase in stress reactivity (Newberry and Swanson, 2008). Indeed, also in dairy cattle farming, these strategies were reported to lead to mixed results (see the “Specific Barriers at the Decision and Transition Stage” section). This suggests that their effectiveness depends on many factors, which should be studied further to improve the application of these strategies. Other interesting strategies to reduce separation distress include contact with (familiar) peers or adults, positive handling by stock people, and housing in a familiar environment. To our knowledge, these strategies have not yet been studied in dairy cattle farming and should therefore be explored in future research. Although there may be important differences between the livestock systems in the way mother-offspring contact is managed and how it affects animal welfare (due to differences in physiology and maternal behavior), the suggested management strategies may all provide some useful solutions to address the practical barriers in CCC implementation. Future research should test the suitability of these strategies for use in dairy cattle farming.

**Further Research Directions.** Not all barriers can be overcome by exploring new management strategies. Indeed, barriers that are based on a farmer’s conceptual objections or insufficient knowledge should be addressed through knowledge transfer strategies that are aimed to inform and educate farmers on CCC systems (Figure 1). The role of research in this is to establish which knowledge transfer strategies are most effective. Some studies have already made steps in this direction (see the “Knowledge Transfer” section), but this should be explored further. Research is also needed to develop effective policies to address practical barriers, such as those relating to economic viability. For instance, research has found that financial incentives could encourage farmers to consider CCC (Wimmer and Frick, 2022) as well as support those that are already practicing it (Bertelsen and Vaarst, 2023). In all future research, it is important to explore the diversity of different CCC systems and study the factors that shape the barriers in more detail by exploring regional differences, farmer demographics, and farm characteristics (including historical background). This would provide a better understanding of the context in which certain barriers arise. An example of a CCC system that needs to be studied more is the foster cow system. Farmers have expressed a preference for this system both in a survey on the opinions of farmers without CCC experience (Boaitey, 2024) and in a study that documented CCC implementation on commercial farms (Wagenaar and Langhout, 2007). However, not much is known about the welfare of cows and calves in these systems. Because

consumers consider foster cow rearing and artificial rearing to be equally undesirable (Sirovica et al., 2022), their objections to this system should be further investigated, as it could represent a compromise during a transition period before the adoption of a dam-rearing system. More insight into the welfare of cows and calves in this system could help to improve its management and shape public opinion. Finally, to ensure that CCC systems are feasible not only for today's farmers, but also for the next generations, research should focus on improving the 4 pillars of sustainability (i.e., governance, social, economy, and environment) of CCC farming (Whalin et al., 2025).

### Knowledge Transfer

Finding new management strategies to address practical barriers is not sufficient if this knowledge is not effectively transferred to the farmers and policymakers. Indeed, the existence of conceptual and knowledge barriers shows that knowledge transfer is not yet effective. Farmers have also noted this themselves, as several farmers mentioned lack of knowledge being a barrier (Eriksson et al., 2022; Hansen et al., 2023). This means that education and dissemination are essential steps in removing barriers both at the decision and transition stages of CCC implementation. Studies have found that programs in which farmers learn from the experiences of other farmers and support each other in the implementation process may be particularly effective (Constancis et al., 2023; Vaarst and Christiansen, 2023; Brunt et al., 2024). In addition, guidelines are needed to support this process, particularly regarding barn design, management, and practices that guarantee the welfare of both cow and calf (Hautzinger et al., 2025). Such guidelines should translate recent research findings in a way that is accessible and understandable for farmers, helping those that are willing to adopt CCC. For instance, many studies have found no effect of CCC on 305-d milk yield (reviewed by Meagher et al., 2019), suggesting that it may be possible to avoid a reduction of saleable milk. Although more research is still needed to better understand exactly how the reduction of saleable milk can be avoided, eventually this knowledge should be communicated to CCC farmers. Guidelines also need to be developed to assist policy makers in the development of policies to effectively support CCC implementation. This should include, for instance, results from economic modeling, as well as surveys on farmers' interest in financial incentives. In general, specific documents should be developed according to the different stakeholders. Dedicated guidelines for on-farm implementations could also be useful for veterinarians, farmer advisors, and veterinary and animal sciences students. Market and industry could benefit from specific suggestions and

quality assurance schemes that include ways to evaluate CCC quality (rearing conditions, bonding and debonding, contact) that could potentially be transferred into labels. Detailed decision-making tools for legislators and authority bodies could allow the inclusion of high animal welfare-friendly CCC in subsidies on a systemic level. Altogether, such strategies would help to build bridges between legislators, farmers, stakeholders, and consumers to shape CCC systems in such a way that benefits animal welfare, farmer wellbeing, and public acceptability.

Similar to research, knowledge transfer strategies should consider that dairy farming is characterized by a high diversity, being practiced in different cultures and environments, with different breeds, housing systems, management strategies and technologies. Although this review clearly showed that knowledge gaps exist regarding the factors that shape the barriers that farmers experience, the first findings show that many factors related to region, farmer demographics and farm characteristics determine which barriers are experienced (Figure 1). It is therefore unlikely that a single CCC system or a single strategy would work for all. To understand which strategy in CCC management works best under different farming conditions requires a great deal of research, as well as trial and error by pioneering farmers.

Although previous reviews have successfully shown the merits of CCC systems, especially relating to animal health and welfare (Johnsen et al., 2016; Beaver et al., 2019; Meagher et al., 2019), this review identified the barriers that keep dairy cattle farmers from transitioning to these systems and explored potential strategies to overcome them. This could help dairy cattle farmers to implement CCC systems in a way that is sustainable for them.

### CONCLUSIONS

This review indicates that CCC practice in contemporary dairy farming remains limited, primarily due to farmer concerns about economic viability, management and staff wellbeing, and animal welfare. Although some concerns (e.g., increased workload) are not confirmed by experiences of farmers that practice(d) CCC, others (e.g., reduced saleable milk, separation distress) are confirmed and warrant the exploration of novel management strategies. This can be aided by exploring strategies from other livestock systems, such as restricted suckling to increase milk yield and group weaning to mitigate separation distress. Research should furthermore be complemented by education and dissemination efforts to foster collaboration among legislators, farmers, stakeholders, and consumers. Such an approach is essential to develop CCC systems that are sustainable, animal welfare-friendly, and publicly acceptable.

## NOTES

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**Nonstandard abbreviations used:** approx. = approximately; CCC = cow-calf contact; NS = not specified.

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## APPENDIX

**Table A1.** Natural weaning age and age of separation in conventional farming for different livestock production systems

Livestock system	Natural weaning age	Conventional separation age (farm)
Beef cattle	6–14 mo (Enriquez et al., 2011; Lynch et al., 2019; Newberry and Swanson, 2008; Weary et al., 2008)	5–9 mo (Rasby, 2007; Enriquez et al., 2011; Lynch et al., 2019; Orihuela and Galina, 2019)
Dairy sheep	6–12 mo (Freitas-de-Melo et al., 2022)	Extensive: 40–45 d/ intensive: 1–2 d (Napolitano et al., 2008; Mora-Medina et al., 2015)
Dairy goat	3–6 mo (Miranda-de la Lama and Mattiello, 2010)	<2 d (Miranda-de la Lama and Mattiello, 2010)
Dairy donkeys	6–12 mo (Dai et al., 2017)	10 mo (French, 1998)
Dairy horses	8–10 mo (Duncan et al., 1984)	7 mo (Miraglia et al., 2020)
Dairy buffaloes	9–11 mo (Bharti et al., 2015)	0–6 d (Bharti et al., 2015; de la Cruz-Cruz et al., 2019; Orihuela et al., 2020)