Bowel Habits in the First 24 Months of Life: Preterm- Versus Term-born Infants

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ABSTRACT

Background and Aim: New prospective studies concerning feeding and bowel habits of term and preterm infants from birth to 24 months of life are needed. The aim of the present study was to describe and compare feeding and bowel habits between term- and preterm-born infants starting from birth up to the age of 24 months.

Patients and Methods: Between August and November 2006 all of the infants admitted to an academic and nonacademic neonatal care unit with gestational age 25 to 42 weeks participated in the study. Bowel diaries were recorded 1 and 2 weeks, and 3, 6, 12, and 24 months after birth. Infants with gastrointestinal surgery, neurological diseases, metabolic diseases, or congenital abnormalities were excluded.

Results: A total of 199 (126 preterm) infants were eligible; 153 gave consent for participation. Although feeding frequency was higher in the first 3 months in the preterm born, overall feeding frequency decreased between the first 3 follow-up periods ($P < 0.001$) in both groups. In the first and second week, breast-fed infants had 2.41 more episodes of defecation per week compared with the formula-fed infants ($P = 0.017$ and $P = 0.021$, respectively). Higher median (10th percentile–90th percentile) defecation frequency was only found in week 1 in the term compared with the preterm group (24 [9.4–31.6] versus 16 [6.5–31]; $P = 0.002$). The overall median defecation frequency was 16 (7–30) per week from birth up to the age of 24 months over the total group of participating infants.

Conclusions: Term and preterm infants have a comparable defecation frequency from the second week of life up to the age of 24 months.

Key Words: bowel habits, breast-feeding, constipation, defecation, stool characteristics, stool consistency

(*JPGN* 2010;51: 753–758)

In the last decade the composition of infant formula feeds has changed dramatically. No data are available, however, evaluating the effect of these changes on bowel habits in the newborn. Moreover, the literature concerning bowel patterns in infants rarely describes normal bowel habits in the first years of life (1–10). The cited studies mainly report defecation frequency and consistency of stools, whereas information concerning amount and color of stools is usually lacking or described retrospectively (11). The latter may be helpful because young parents are often uncertain about these specific aspects of stool. We recently published the Amsterdam Infant Stool Form Scale, which provides information concerning stool amount, consistency, and color (12). This Stool Form Scale is, however, only a ''snapshot'' of the situation and therefore gives no information about the changes in stool characteristics during a longer period of time (12).

The necessity for more prospectively obtained data concerning infants and young children is mandatory, not only to define normal bowel habits but also to recognize abnormal bowel habits such as constipation. Although the Rome III criteria defined functional constipation for children younger than 4 years, well-defined criteria for the youngest infants are lacking. New data with respect to symptomatology may be helpful to set new criteria to differentiate between normal bowel habits and constipation in this specific age group. The latter is particularly important because bowel habits change in the first months of life, not only because of aging but also as a result of change in feeding habits (2–9,13).

Therefore, the aim of the present study was to describe and compare feeding and bowel habits in term- and preterm-born infants including feeding and defecation frequency, consistency, and amount and color of stool in a cohort of newborn infants up to the age of 24 months.

PATIENTS AND METHODS

Patients

Between August and November 2006, all of the infants with gestational age (GA) 25 to 42 weeks were eligible for participation. Infants admitted to the neonatal care units of an academic (Emma Children's Hospital/Academic Medical College) and a nonacademic hospital (Onze Lieve Vrouwe Gasthuis) in Amsterdam, the Netherlands, were included in the study immediately after birth. Infants were divided into 2 groups: term born, GA $\geq$ 37 weeks and preterm born, GA $\leq$ 36 weeks. Infants with a history of gastrointestinal (GI) surgery (anal atresia, Hirschsprung disease), necrotizing enterocolitis, neurological disease (spinal bifida), metabolic disease (cystic fibrosis, hypothyroid), or congenital abnormalities (Down syndrome), as well as infants who died during the study period were excluded from the study.

Bowel Diaries

Bowel habits were recorded by using standardized bowel diaries, which included information about defecation frequency per week, stool consistency, amount and color of stool, pain during defecation, and the presence of GI symptoms such as flatulence,

Received August 8, 2009; accepted January 19, 2010.

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The authors report no conflicts of interest.

DOI: 10.1097/MPG.0b013e3181d7c809

vomiting, abdominal cramps, and abdominal distension. Use of laxatives was also recorded in the diaries. Bowel diaries were daily recorded in the first 2 weeks of life by the researchers during hospital admission of the infant (passive participation) or by parents (active participation). At the age of 3, 6, 12, and 24 months after birth, daily bowel diaries were recorded for 7 consecutive days by the caretakers. At the age of 24 months after birth, additional information was gathered with respect to toilet training.

Informed Consent and Follow-up

The hospital's medical ethics committee approved the research protocol. Parents gave written consent. At follow-up, new bowel diaries were sent by post (or e-mail) including a covering envelope. A second bowel diary was sent when the bowel diaries were not sent back in time. Hereafter, parents were called by telephone to verify the reason for the loss to follow-up.

Data Analysis and Interpretation

Patients' characteristics were documented descriptively. Amount and frequency of feeding were analyzed using the Student *t* test. In a univariate linear regression model the independent effect of type of feeding on defecation frequency was examined. We compared the defecation frequency across babies with different types of feeding (categorical). A log transformation (base 10) was performed on the defecation frequency because of its skewed distribution. Results, therefore, are expressed as geometric means.

Difference in defecation frequency between preterm- and term-born infants was expressed in median values (10th percentile–90th percentile) and analyzed using the Wilcoxon rank test. Amount, consistency, and color were documented descriptively. The total number of symptoms was described in median values (minimum–maximum) and analyzed using the Kruskal-Wallis test. Difference in presence (yes/no) of GI symptoms was tested using (Yates continuity corrected) χ^2 statistics or Fisher exact test, depending on cell frequencies.

All of the other values were expressed in mean ± SD or median (10th percentile–90th percentile). Statistical significance was defined as $P < 0.05$. All of the analyses were performed using the statistical software package SPSS (version 14.0, SPSS Inc, Chicago, IL).

RESULTS

Baseline

A total of 199 infants (126 premature) were eligible during the study period with mean GA of 35 ± 4 weeks; 153 parents gave consent for participation during hospital admission (Fig. 1). The lost to follow-up rate was highest at the age of 3 months (34%) and lowest at 24 months (17%). Reasons for lost to follow-up included drug-addicted mothers (n = 2), parents with psychological problems (n = 1), emigration (n = 3), GI surgery (n = 2), language problems (n = 6), and too busy (n = 37, of whom n = 18 because of having twins), whereas all others gave no specific reason for noncompliance with the study diaries.

Feeding

Feeding Frequency

Feeding frequency was different between the 2 groups in the first 3 months of life. Term-born infants had lower feeding frequency per day in the first week (6.9 ± 1.9 vs 9.2 ± 3.7; $P < 0.001$), the second week (7.7 ± 1.5 vs 10.2 ± 3.7; $P = 0.001$), and the third month of life (6.4 ± 0.9 vs 7.9 ± 2.2; $P = 0.002$) compared with preterm-born infants.

Comparing the feeding frequency between the follow-up periods, a significant difference in feeding frequency was found between week 1 and week 2 (8.9 ± 3.2 and 9.7 ± 3.2; $P < 0.001$), between week 2 and month 3 (9.7 ± 3.2 and 7.2 ± 1.8), and between month 3 and month 6 (7.2 ± 1.8 and 4.8 ± 0.8; $P < 0.001$) in both groups.

Amount of Feeding

As expected the total amount of enteral feeding (fluid) 1 week after birth was higher in the term-born group compared with the preterm group (Table 1). Total amount of feeding per kilogram of weight, however, was comparable between both groups during the first week of life ($P = 0.12$).

Bowel Habits

Defecation Frequency

As shown in Table 1 and Figure 2 in week 1, the median defecation frequency per week was higher in the term-born group

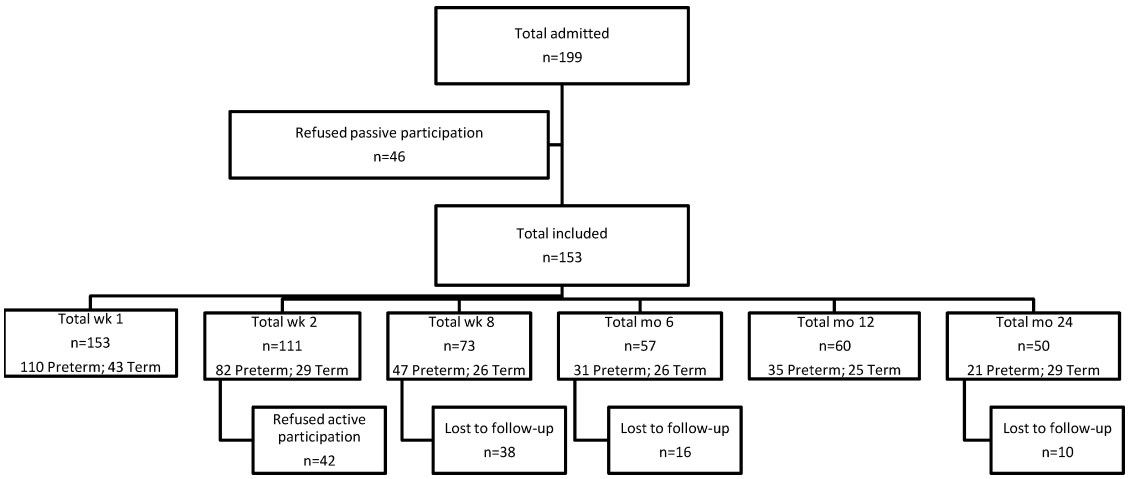

FIGURE 1. Flowchart of participating infants.

TABLE 1. Median (p_{10}-p_{90}) DFW from birth to the age of 24 mo

	Term median DFW (p_{10}–p_{90})	Premature median DFW (p_{10}–p_{90})	*P*	Term mean ± SD mL feeding/day	Premature mean ± SD mL feeding/day	*P*
Wk 1	24 (9.4–31.6)	16 (6.5–31)	0.002	285 ± 153	146 ± 145	0.001
Wk 2	24 (10–36)	24 (12.7–33)	0.93	287 ± 114	197 ± 143	0.17
Mo 3	8.5 (3.7–27.6)	16 (3–34)	0.06	568 ± 45	381 ± 137	0.02
Mo 6	12 (7–26.2)	12 (3–25)	0.69	180 ± 40	204 ± 110	0.67
Mo 12	14 (6.6–23.8)	16 (8–21)	0.59	288 ± 236	380 ± 287	0.33
Mo 24	9.9 (5–14.7)	9 (5.8–15.4)	0.78	763 ± 474	633 ± 375	0.31

DFW = defecation frequency per week.

(24 [9.4–31.6]) compared with the preterm group 16 [6.5–31]; $P = 0.002$). This difference remained after excluding infants receiving morphine and/or no enteral feeding (18 [9–38.4]; $P = 0.04$) in week 1. Overall median defecation frequency was 16 (7–30) per week from birth to the age of 24 months over the total group of participating infants.

Feeding (Type) and Defecation

During week 1 and week 2, median defecation frequency was higher in the breast-fed infants. In the first and second week of life, breast-fed infants had 2.41 more episodes of defecation per week compared with the formula-fed infants ($P = 0.017$ and $P = 0.021$, respectively).

In the term-born infants, feeding frequency and defecation were correlated in week 1 ($r = 0.75$; $P < 0.001$) and week 2 ($r = 0.29$; $P = 0.02$), whereas in the preterm group, feeding frequency and defecation were correlated in week 1 and month 3 ($r = -0.21$; $P = 0.04$ and $r = 0.35$; $P = 0.03$, respectively).

Stool Characteristics

Stool characteristics of both groups are depicted in Table 2. With aging, amounts (volume) of stools in term-born infants remain large or normal whereas preterm infants start with little amounts of stools (72%) in week 1 changing into large or normal (80%) at later age. Stool consistency was normal/soft during the entire period of follow-up in both groups. Color of stools changed from mainly yellow and green into brown at later age in both groups.

Gastrointestinal Symptoms

As depicted in Table 3, the total number of GI symptoms was higher in the term-born group (2 [0–7] compared with the preterm group 1 [0–5]) at 2 weeks follow-up, $P = 0.001$). Thereafter, up to the age of 24 months no differences were found in the total number of GI symptoms between both groups.

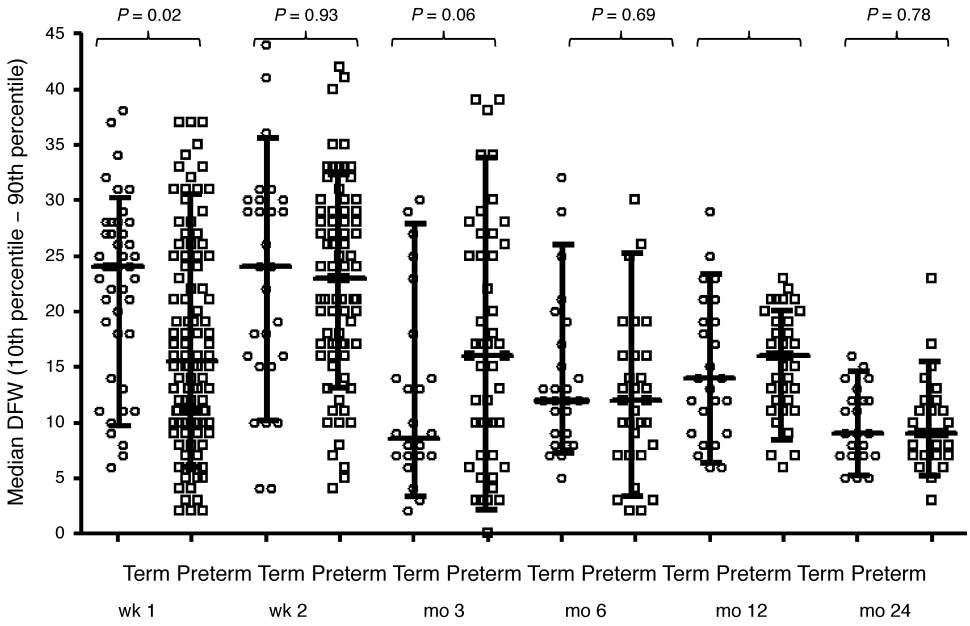

FIGURE 2. Median (p_{10}-p_{90}) defecation frequency per week for the ages of 1 and 2 weeks and 3, 6, 12, and 24 months after birth, respectively. Difference in values was analyzed using the Wilcoxon rank test.

TABLE 2. Stool characteristics from birth to the age of 24 mo

	Wk 1		Wk 2		Mo 3		Mo 6		Mo 12		Mo 24	
	Term	Preterm	Term	Preterm	Term	Preterm	Term	Preterm	Term	Preterm	Term	Preterm
Amount												
Much	6	7	16	12	37	22	25	19	49	20	6	12
Normal	84	15	70	74	50	57	62	62	40	68	89	68
Little	6	72	8	12	6	9	11	18	11	11	5	20
Smear	2	5	0	2	6	3	2	1	0	1	0	<1
Unknown	2	1	6	—	1	9	—	—	—	—	—	—
Consistency												
Meconium	26	53	1	11	—	—	—	—	—	—	—	—
Hard	0	5	5	8	1	4	3	7	5	6	9	3
Normal/soft	67	40	85	79	90	89	91	86	92	89	91	97
Watery	4	1	9	2	9	7	6	7	3	5	0	0
Unknown	3	1	—	—	—	—	—	—	—	—	—	—
Color												
Yellow	54	26	90	68	76	89	47	39	12	6	Not recorded	
Green	40	67	9	24	21	9	30	40	12	12	—	—
Brown	3	7	1	5	3	2	18	20	72	80	—	—
Orange	0	0	0	0	0	0	5	1	4	2	—	—
Unknown	3	0	0	3	0	0	0	0	0	0	—	—

Data have been represented as percentage. Not recorded accounts for all colors of stools in the 24-mo follow-up period.

Constipation and Laxative Treatment

Despite the lack of a clear definition for constipation for young infants, a total of 7 term-born infants versus 31 preterm-born infants were treated with laxatives (once or more) during the first 24 months of life by their pediatricians; $P = 0.04$ (Fig. 3).

Only 2 preterm infants initially treated with laxatives continued laxatives at week 2 and month 3 of follow-up. One infant was treated with laxatives at week 1 and month 3. All other 12 infants stopped laxative treatment after the first week of life. Infants who started with laxatives at the age of 12 months discontinued treatment at follow-up. Interestingly, no difference was found in type of feeding between those infants.

The reasons for pediatricians to start treatment for constipation varied from unsatisfying stool characteristics (hard or small amounts) and low defecation frequency to symptoms such as straining and abdominal distension (Fig. 3).

Toilet Training

At the last follow-up period, 7 (33%) and 9 (31%) infants from the term- and premature-born group started toilet training at the age of 20.7 ± 2.8 and 20.7 ± 7.4 months, respectively ($P = 0.99$). None of these infants was toilet trained by the age of 24 months.

DISCUSSION

In the present prospective study, we demonstrated that breast-feeding was positively correlated with defecation frequency in only the first 2 weeks of life in both term- and preterm-born infants. The frequency of feeding was statistically higher in the term-compared with preterm-born infants in the first 3 months of life. Furthermore, term-born infants and preterm-born infants had comparable defecation frequency from the second week of life up to the age of 24 months.

In contrast to other studies, we demonstrated that breast-feeding, unlike formula feeding, was associated with significantly higher defecation frequency in only the first 2 weeks of life (4,9,13). The landmark study by Weaver et al (9) showed, however, a higher defecation frequency in the first 8 weeks of life in breast-fed infants. Breast-fed infants opened their bowels 4 times per day compared with 2.75 in the formula-fed infants (9). A possible explanation for our observation may be the change in the composition of infant formula, which presently resembles breast-feeding. Indeed, in accordance with our results more recent studies showed comparable defecation frequency between infants who were formula- or breast-fed (14,15). Moreover, feeding containing more bifidobacteria, resembling breast-feeding, is associated with higher defecation frequency and fewer incidences of constipation than standard formula feeding (16).

Comparison of term-born with preterm-born infants revealed higher defecation frequency in the term born in the first week of life. Possible explanations are 2-fold: the preterm group consisted of infants younger than 34 weeks of gestation with a yet-to-further-develop motility pattern. For example, at 32 weeks of gestation McLain (17) observed that progression of contrast material from proximal to distal colon took as long as 9 hours, taking only half of that time at the term age. Furthermore, in preterm piglets dysfunctional enteric neurons in combination with inappropriate gut hormone release such as motilin and gastrin are decreased. In infants, however, increase in gut regulatory hormones in response to feeding is comparable between term and preterm infants with similar responses occurring for breast-feeding and formula feeding (18,19). This does not preclude the possibility that a functional immaturity of such cells and their receptors contributes to a disturbed GI motility response to enteral feeding in preterm neonates

TABLE 3. Median number of total GI symptoms and total number of infants with specified GI symptoms at each follow-up period

	Term vs preterm											
Symptoms	Wk 1 n = 43	Wk 1 n = 110	Wk 2* n = 29	Wk 2 n = 82	Mo 3 n = 26	Mo 3 n = 47	Mo 6 n = 26	Mo 6 n = 131	Mo 12 n = 25	Mo 12 n = 35	Mo 24 n = 29	Mo 24 n = 21
Median no. symptoms (min–max)	0 (0–6)	1 (0–8)	2 (0–7)	1 (0–5)	3 (0–7)	2 (0–7)	2 (0–5)	3 (0–6)	3 (0–6)	2 (0–5)	2 (0–4)	1 (0–7)
Total no. GI symptoms	36	27	66	54	63	80	54	62	47	91	40	47
Abdominal pain, no. (%)	9 (25)	0	17 (26)	8 (15)	15 (24)	13 (16)	6 (11)	10 (16)	3 (6)	5 (6)	1 (2)	2 (4)
Diarrhea, no. (%)	1 (3)	0	8 (12)	16 (30)	5 (8)	7 (9)	8 (15)	3 (5)	5 (11)	13 (14)	8 (20)	9 (19)
Flatulence, no. (%)	8 (22)	0	15 (23)	3 (5)	15 (24)	15 (19)	15 (28)	13 (21)	19 (40)	28 (31)	15 (38)	16 (34)
Vomiting, no. (%)	5 (14)	8 (30)	8 (12)	5 (9)	6 (9)	7 (9)	3 (6)	4 (6)	1 (2)	5 (6)	0	2 (4)
Crying at defecation, no. (%)	3 (8)	0	5 (7)	2 (4)	5 (8)	10 (12)	1 (2)	10 (16)	24 (51)	4 (4)	1 (2)	2 (4)
Red face at defecation, no. (%)	6 (17)	0	7 (11)	2 (4)	9 (14)	18 (23)	11 (20)	12 (19)	12 (26)	21 (23)	6 (15)	9 (19)
Distended abdomen, no. (%)	4 (11)	19 (70)	6 (9)	18 (33)	8 (13)	10 (12)	10 (18)	10 (16)	7 (15)	13 (14)	9 (23)	7 (15)
Alarms, no. (%) (apneas, bradycardia)	2 (5)	53	0	20	—	—	—	—	—	—	—	—

GI = gastrointestinal.
* Significant difference ($P = 0.001$) between the 2 groups in the total number of symptoms.

(20). The higher volumes of enteral feeding, consumed by the term-born infants, increase defecation frequency (5,13) as a result of the gastrocolonic response to gastric distension by feeding (21–23).

Feeding frequency was correlated with defecation in the first 2 weeks of life. The correlation values, however, were low and therefore can describe this association only partly. Indeed, a recent study described that the most important factor affecting defecation frequency was age (11); however, a prospective study including 611 infants showed a clear significant correlation (13). The number of infants included in our study may have contributed to the weak correlations found.

Comparable to other studies describing a defecation frequency of 1 to 2 per day in infants younger than 2 years, we found a median defecation frequency of 16 (p_{10}-p_{90}: 7–30) per week during the total follow-up period of 24 months (4,8,24). Based on those latter studies and our data, we may conclude that infants younger than 24 months of age should at least open their bowels once daily. Therefore, we suggest an adjustment to the Rome III criterion, defecation frequency, to <1 per day rather than <3 per week for constipation in infants 24 months and younger (25,26).

Interestingly, 38 infants from our cohort were treated with laxatives for reasons other than low defecation frequency, such as hard stools, small amounts of stools, and straining, and also for abdominal distension. Because the Rome III criteria lack clear definitions for constipation in the younger age group, clinical experience is often the reason to start laxative treatment. The results of the present study in combination with the use of the Amsterdam Infant Stool Form Scale hopefully will lead to a more scientifically based treatment of infants with defecation problems (12). Besides defecation frequency, hard stool is a good candidate for characterizing constipation in infancy. The present study showed that hard stool was 1 of the main reasons to start laxative treatment. Previously, Loening-Baucke (27) also showed that hard consistency of stools and hard bowel movements were found in the majority of patients with constipation younger than 2 years. Moreover, the latter study also showed that only 13% of the children with constipation had defecation frequency <2 per week. Therefore, large prospective or cross-sectional studies including infants from different age groups are necessary to further describe specific stool characteristics using a standardized stool scale. Additionally, quantification of exact frequency and abdomen circumference is needed for symptoms concerning low defecation frequency and abdominal distension, respectively.

The present study had also shortcomings such as the loss to follow-up rate of 33% in the 2 years follow-up, which was higher compared with other studies, 19% to 21%, with a follow-up period between 3 and 4 years (28,29). A possible explanation for this difference may be that our population was partly healthy and not studied by any physician, making the follow-up data more difficult to obtain. Even those studied in the outpatient clinic had no close relation to the GI outpatient clinic conducting the study. Another shortcoming is that data about possible comorbidities later in life were not collected in the bowel diaries. Also, exact type of feeding (eg, with or without probiotics) was not collected. Given the dramatic change in types of formula feeding, such an overview would have been interesting; however, the number of infants at the end of study would possibly have been too small to demonstrate a significant difference.

In conclusion, the present prospective study demonstrated that breast-feeding was positively correlated with defecation frequency in only the first 2 weeks after birth. Furthermore, term-born infants and preterm-born infants had comparable defecation frequency, of at least 1 bowel movement per day, from the second week of life up to the age of 24 months. Therefore, we recommend changing the item defecation frequency in the Rome III criteria for

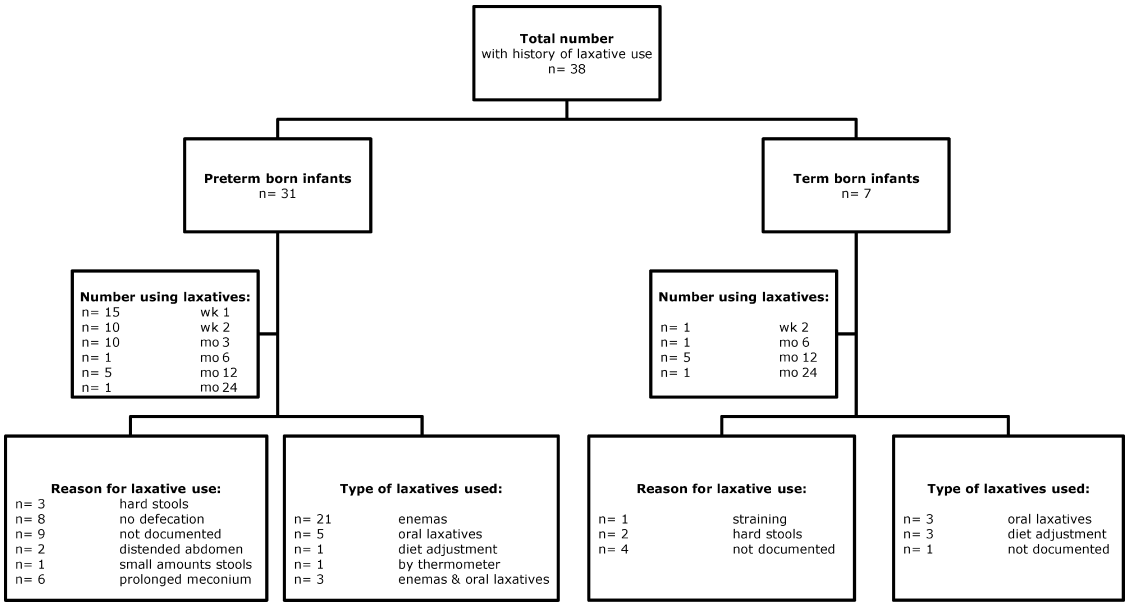

FIGURE 3. Overview of laxative use in all of the infants during the first 24 months of life.

constipation in children younger than 4 years of age. The defecation frequency in those infants younger than 24 months should be less than once per day rather than a defecation frequency of <3 per week. Additional symptoms such as hard stools or straining, together with defecation frequency of <1 per week, would justify starting laxative treatment for infants.

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