British Association of Perinatal Medicine

Prevention and management of metabolic bone disease of prematurity

A DRAFT Framework for Practice

March 2026

Contents

Purpose and scope

This framework of practice aims to

- Highlight the importance of optimising enteral and parenteral nutrition to prevent MBDP among high-risk infants.
- Provides recommendations for appropriate screening and management options.

This framework is NOT or out of scope for:

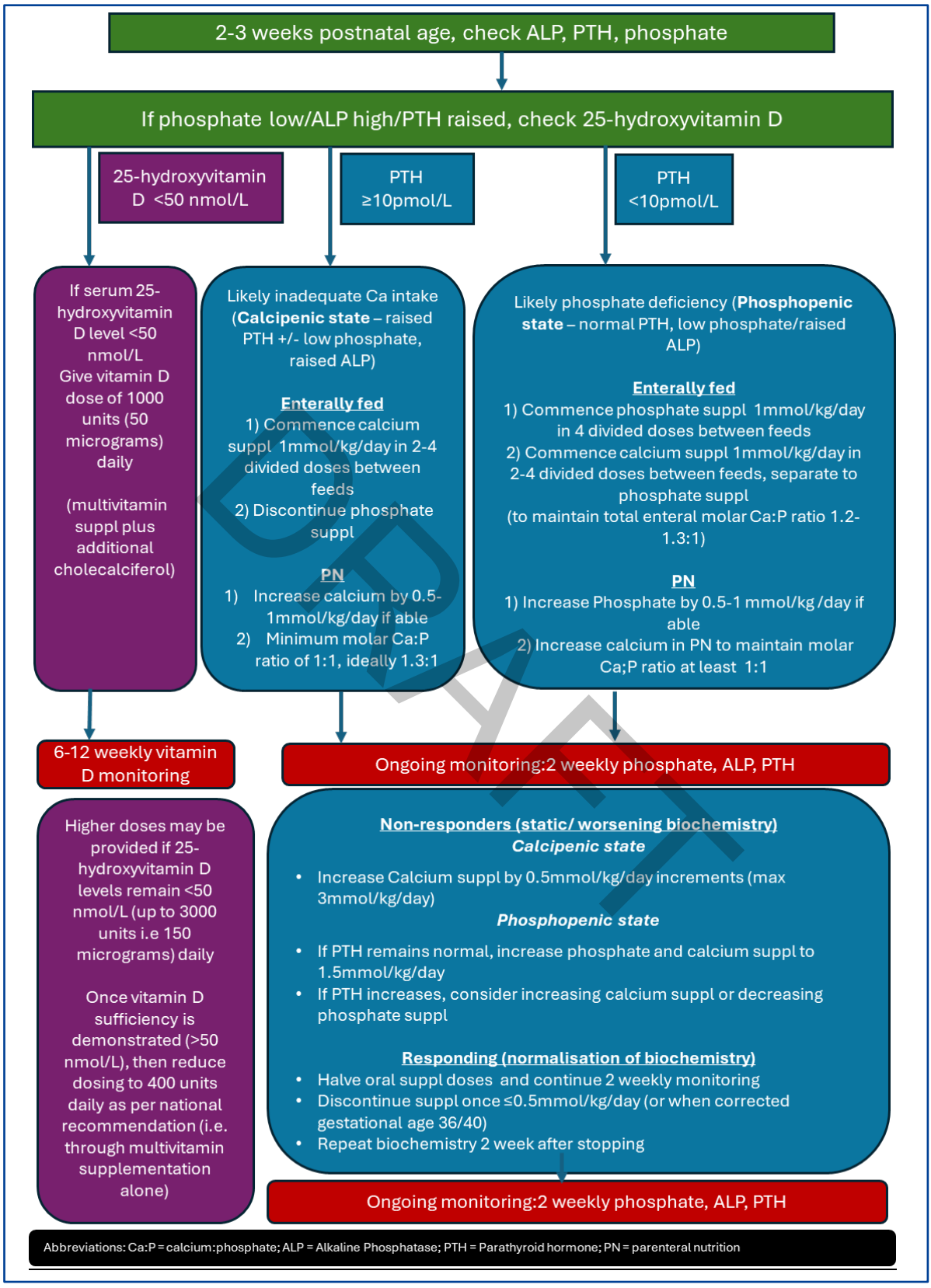
- Derangements in calcium and phosphate that occur within the first week of life in preterm infants.
- Disorders resulting in neonatal hypocalcaemia or hypercalcaemia.
- Hypophosphatemia due to renal phosphate wasting disorders.
- Deranged ALP and bone metabolism due to liver and renal disorders.
- Management of bone fragility and fractures, or other disorders that can cause bone fragility in infancy.
- Derangements in bone metabolism in term infants (this is not usually due to MBDP – alternative diagnoses should be considered).

If there is doubt as to the diagnosis of MBDP, a discussion with a specialist in paediatric bone metabolism is advised.

Executive summary/ Key recommendations

Question and Recommendation	Evidence quality	Strength of recommendation
How should we prevent metabolic bone disease of prematurity (MBDP)? Prevention of MBDP relies on identification of at-risk infants in whom to implement optimal enteral and parenteral nutritional strategies and maintaining vitamin D levels	**Moderate**	**Moderate/strong**
Which babies should be screened with biochemical tests for MBDP? • Gestational age at birth <32 weeks or Birth weight <1500 grams • Prolonged duration of parenteral nutrition (> 4 weeks) or Prolonged (>2 weeks) or recurrent (>1 course) use of steroid treatment	**High** **Moderate**	**Strong** **Moderate**
When should we consider screening? • No earlier than 2-3 weeks postnatal age • After enteral nutrition is optimised (unless receiving prolonged parenteral nutrition)	**Very low** **Very low**	**Weak** **Consensus**
What tests should be done and how often? • Fortnightly serum alkaline phosphatase (ALP), phosphate and parathyroid hormone (PTH)	**Moderate**	**Weak/moderate**
When should we consider treatment for MBDP? ALP >650 U/L and/or Phosphate <1.8 mmol/L and/or PTH >10 pmol/L	**Moderate**	**Weak/moderate**
What is the treatment and monitoring of MBDP? Flow chart 1 below summarises a treatment and monitoring pathway once MBDP is established and nutrition has been optimised. Management depends on whether the infant is in a calcipenic or phosphopenic state.	**Very low**	**Consensus**

Flow chart 1. Summary of treatment and monitoring pathway, once suggested by routine biochemical screening, and once preventative strategies and nutrition have been optimised.



Blue boxes: Key to the supplementation strategy is whether PTH is elevated (≥10 pmol/L) or not, and therefore whether there is a relative calcipenic or phosphopenic state. Once supplementation is commenced, fortnightly monitoring of biochemistry (ALP, PTH, phosphate) will guide adjustments to, and discontinuation of, supplementation. Purple boxes: Of secondary importance is the optimisation of 25-hydroxyvitamin D levels if deficient.

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Introduction

Metabolic bone disease of prematurity (MBDP) refers to the undermineralisation of the skeleton, which commonly occurs in infants born preterm (Angelika et al., 2021, Levene et al., 2023, Lyon et al., 1987, Mitchell et al., 2009). It is due to loss of the accretion of calcium and phosphorus minerals (80% of which occurs in the third trimester in utero), which is challenging to replicate postnatally through enteral or parenteral nutrition, and exacerbated by risk factors which affect bone mineral metabolism (Chinoy et al., 2019, Forster et al., 2024). Therefore, in essence, MBDP is primarily due to a deficiency in calcium and phosphorus minerals.

Mineral deficiency leads to undermineralisation of the bones (characterised by osteopenia, with elevations of alkaline phosphatase as the body tries to increase bone mineralisation and turnover) and rickets (due to low serum phosphate, either due to phosphorus deficiency or secondarily due to the effects of elevated parathyroid hormone in response to calcium deficiency which results in renal phosphate wasting) (Chinoy et al., 2019).

Historically, there was a presumption that inadequate dietary phosphate was the leading reason for MBDP and alkaline phosphatase was the main biochemical marker (Lucas et al., 1989). However, it is now known that inadequate dietary calcium may also contribute to MBDP, and excessive phosphate supplementation can lead to secondary hyperparathyroidism (Chinoy et al., 2019, Boddu and Lankala, 2022).

In extremely preterm infants, it is likely that protein deficiency may also contribute to MBDP, due to inadequate osteoid formation in the bone to subsequently mineralise (Czech-Kowalska, 2020). This framework does not specifically address protein provision, in the absence of evidence specifically in relation to outcomes in MBDP. However, following current guidance on enteral and parenteral provision of protein to preterm infants published elsewhere is advised, due to its positive outcomes on growth (Brown et al., 2024, Embleton et al., 2023, Embleton and van den Akker, 2019, van Goudoever et al., 2018). Due to paucity of evidence, no national or international guidance exists for the management of MBDP, and clinical practice is varied (Chinoy et al., 2021, Harrison et al., 2008). MBDP is important to prevent, recognise and manage effectively, so as to avoid its consequences. Although this has not been fully explored, there is evidence to suggest MBDP worsens respiratory outcomes (Avila-Alvarez et al., 2020), has implications on growth in infancy and childhood (Fewtrell et al., 2000, Lucas et al., 1989) and can make the bones fragile, increasing the risk of pathological fractures, both whilst on the neonatal unit and following discharge. This can cause issues in separating between fragility fractures and non-accidental injury which can complicate safeguarding processes (Boddu and Lankala, 2022, Chinoy et al., 2019, Lucas-Herald et al., 2012).

This framework aims to harmonise broad practice across the UK and suggests an approach to MBD prevention, screening and treatment. This framework highlights i) the importance of a nutritional preventive strategy in at-risk infants ii) the importance of maintaining a physiological ratio of calcium to phosphate to avoid disordered bone mineralisation. iii) importance of testing parathyroid hormone (PTH) in addition to the bone profile to determine whether MBDP is due to primary calcium deficiency or primary phosphate deficiency, to guide further management.

In recognition of existing areas of uncertainty, the strength and quality of evidence is presented alongside each recommendation. A care pathway is suggested which can be used to inform local guidelines. It is important to highlight that this framework provides guidance from an MBDP perspective only, and clinical decisions need to be made in the context of the whole clinical picture at an individual patient level.

Terminology: Phosphorus vs phosphate

In this framework, **phosphorus** refers to the mineral that is required for bone mineralisation, and **phosphate** refers to the measured ion in serum as a screening tool, and to the medication that is given in phosphopenic states. This differentiation is important in calculating optimal ratios. Ratios are provided in millimoles given the ratios are equivalent with calcium for both phosphorus and phosphate. If milligrams was used, ratios differ because of different molar weights between phosphorus and phosphate.

Evidence review to inform recommendations and grading

Recommendations in this framework were informed by published literature, unpublished work and clinical experience or consensus where no evidence was available. Members of the working group conducted literature searches focusing on questions surrounding prevention, screening and treatment of MBDP (see Appendices 1 & 2). A modified Delphi approach was used to achieve consensus within the working group (with repeated rounds until 75% consensus was achieved on all areas). Grading of the strength of the recommendations are provided based on the quality of evidence (Strong/Moderate/Weak) or consensus where no evidence is available.

Clinical questions and recommendations

1. How should we prevent metabolic bone disease?

Recommendation	Evidence quality	Strength	Rationale for the recommendation
Identification of at-risk infants: - <32 weeks gestation - Birth weight <1500 grams - Prolonged duration of parenteral nutrition (>4 weeks) - Prolonged (>2 weeks) or recurrent (>1 course) use of steroids - Prolonged or recurrent use of diuretics (especially furosemide)	**High** **High** **Moderate** **Moderate** **Low**	**Strong** **Strong** **Moderate** **Moderate** **Weak**	Studies have identified these as risk factors for development of MBDP, presumably due to loss of in utero mineral accretion (gestation, BW), placental insufficiency (BW), provision of minerals (PN) and impact on bone metabolism (steroids, diuretics)
Implement optimal enteral nutrition strategies: - From an MBDP perspective, fortification of maternal breast-milk (or donor breast-milk) with multinutrient breast-milk fortifier facilitates the provision of adequate nutrient requirements - When formula is used, a preterm-specific milk formula should be selected	**Moderate** **Moderate**	**Strong** **Strong**	Neither breast milk alone, nor term formulas provide adequate calcium and phosphorus to meet preterm requirements (ESPGHAN) (Embleton et al., 2023)
Maximise calcium and phosphate in parenteral nutrition: - Minimum molar calcium:phosphate ratio of 0.75-1:1 - Optimise to molar calcium:phosphate ratio of 1.3:1	**Moderate** **Very low**	**Moderate/strong** **Weak**	Neither breast milk alone, nor term formulas provide adequate calcium and phosphorus to meet preterm requirements (ESPGHAN) (Embleton et al., 2023)
Supplement enteral feeds or parenteral nutrition with multivitamin supplementation containing 400-1000 international units (20-50 micrograms) of vitamin D per day	**High**	**Moderate/strong**	In line with ESPGHAN recommendations (Embleton et al., 2023)

Further information

Multiple studies have consistently identified gestational age and birth weight as the two key risk factors for MBDP, in particular infants <28 weeks gestation or with a birth weight <1000 grams. Other risk factors have been postulated in the literature (e.g. chronic lung disease, necrotising enterocolitis, use of ranitidine and caffeine), but the contribution these made to the development of

MBDP may be confounded by other risk factors above and therefore the review group felt there was insufficient evidence to support them as definite risk factors. Routine use of prophylactic phosphate supplementation should not be in isolation; This may worsen MBDP by driving secondary hyperparathyroidism in calcipenic situations.

Breast milk is preferred to formula milk for all infants regardless of gestation due to its nutritional advantages and proven protective effect against necrotising enterocolitis and late onset sepsis (Eidelman, 2012, Vohr et al., 2007, Belfort et al., 2016, Corpeleijn et al., 2016, Patel et al., 2013, Miller et al., 2018, Meinzen-Derr et al., 2009, Taylor et al., 2021, Quigley et al., 2019, Brown et al., 2019, Valverde et al., 2021). Additionally, in the context of MBDP, there is evidence for greater micronutrient availability and absorption (Grover et al., 2024, Mastroeni et al., 2006, Roig, 1999). Recent ESPGHAN guidance proposes early fortification once an infant is tolerating 40-100ml/kg of breast milk (Embleton et al., 2023, Arslanoglu et al., 2019). Both fortified expressed breast-milk and most preterm formulae have a calcium-to-phosphorus ratio of ~1.3:1 on a molar basis, which allows optimal absorption of both minerals (Abrams and Committee on, 2013) (see Appendix 3).

Estimated recommendations for enteral vitamin D of 400-700 IU can only be achieved with additional multivitamin supplementation, even for infants on fortified breast milk and preterm-specific infant formula (Abrams and Committee on, 2013, Embleton et al., 2023, Kumar et al., 2022). For infants on PN (both short term and prolonged use), vitamin D should be given as part of the fat-soluble vitamins component. The total provision of vitamin D is dependent on the weight of the infant – it should be noted that for infants less than 2.5kg this is likely to be less than 400IU. Therefore, enteral supplementation with a multivitamin containing vitamin D should also be considered for infants on long-term partial PN if the enteral route is not contraindicated (Bronsky et al., 2018).

Whilst there is a paucity of evidence, it is important to highlight the importance of optimal handling and positioning given the. potential for bone fragility [consensus]. This will reduce risk of fragility fractures but also promote bone health via muscle stimulation (Rauch and Schoenau, 2002). There remains insufficient evidence at present to support the use of passive physical activity regimens.

2. Which babies should we screen (biochemical blood tests) for MBDP?

Recommendation	Evidence quality	Strength	Rationale for the recommendation
Infants with any of the following should be screened for MBD: • Gestational age at birth <32 weeks or birth weight < 1500 grams • Prolonged duration of parenteral nutrition (> than 4 weeks) • Prolonged (> 2 weeks) or recurrent (>1 course) use of steroid treatment	**High** **Moderate** **Moderate**	**Strong** **Moderate** **Moderate**	As per section above

3. When should we consider screening for MBDP?

Recommendation	Evidence quality	Strength	Rationale for the recommendation
No earlier than 2-3 weeks postnatal age, but only after enteral nutrition is optimised (unless receiving prolonged PN)	**Very low**	**Weak**	Biochemical derangements will begin to be seen from 2-3 weeks postnatal age. However, nutrition must be optimised prior to prevent unnecessary supplementation being commenced

Further information

The limited literature suggests that biochemical derangements due to MBDP start to occur at around 2-3 weeks of life (Hung et al., 2011, Lee et al., 2017, Rayannavar and Calabria, 2020). This allows for early detection and timely initiation of treatment, whilst avoiding unnecessary interventions in the immediate postnatal period. Although screening should ideally commence only after establishing optimal enteral nutrition, if an infant is on prolonged PN, then earlier screening can be implemented.

4. What tests should be done, how often and what are the thresholds to suggest MBD treatment?

Recommendation	Evidence quality	Strength of recommendation	Rationale for the recommendation
Test and thresholds suggestive for MBDP treatment 1. Alkaline phosphatase, >650 U/L	**Moderate**	**Moderate**	Although ALP thresholds range from 500-700 U/L, highest quality evidence available suggests ALP >650 U/L
2. Phosphate, <1.8 mmol/L although laboratory dependent and varies with age	**Moderate**	**Weak/moderate**	Acceptable sensitivity (50%) and optimal specificity (96%) with threshold of <1.8 mmol/L
3. Parathyroid hormone, PTH; >10 pmol/L [moderate/weak]	**Moderate**	**Weak/moderate**	As well as guiding treatment, PTH also serves as an early screening measure of MBDP – a reference range in preterm infants has been established as 0.9-11.9 pmol/L, with 10 pmol/L felt to be a pragmatic choice
25-hydroxyvitamin D to be measured (aim >50 nmol/L) only if any of the main biochemical screening parameters are abnormal on screening	**Very low**	**Consensus**	There is insufficient evidence to justify routine 25-hydroxyvitamin D testing, but it is important to treat vitamin D deficiency once MBDP is diagnosed
How often? Two weekly	**Very low**	**Consensus**	To allow for appreciation of trends in biochemistry, timely initiation of treatment, without excessive sampling, and in line with routine blood tests

Further information

A combination of biochemical markers, particularly elevated PTH and low phosphate, carries a greater sensitivity and specificity of diagnosing MBDP than reliance on individual markers (Backstrom et al., 2000, Figueras-Aloy et al., 2014, Moreira et al., 2014).

Alkaline phosphate: There are comparatively many more studies of ALP thresholds (than the other biochemical thresholds) in the detection of bone disease in preterm infants (Abdallah et al., 2016, Backstrom et al., 2000, Czech-Kowalska et al., 2016, Faerk et al., 2002, Hung et al., 2011, Koo et al., 1982, Lee et al., 2017, Lu et al., 2023, Mitchell et al., 2009, Moreira et al., 2014, Tkach et al., 2017, Viswanathan et al., 2014). The highest quality evidence available indicates that a peak ALP of >650 U/L is associated with a sensitivity of 80% and a specificity of 64% for predicting MBDP (Lee et al., 2017). The trends, as well as the absolute values of ALP, are useful in assessing for MBDP.

PTH: Elevated PTH is a physiological marker of calcium deficiency. There is evidence to suggest that elevated PTH is, even in isolation, one of the strongest indicators of MBDP and its sequalae and may represent the first or only biochemical derangement in the calcipenic state (Czech-Kowalska et al., 2016, Levene et al., 2023, Moreira et al., 2014). Therefore, this framework recommends that PTH is part of the screening bloods undertaken, rather than only performed if ALP or phosphate is deranged, as is common practice in some centres. There is a paucity of studies investigating thresholds for PTH in neonates (Matejek et al., 2018); Typically childhood and adult reference ranges have been applied to preterm infants. However, a recent well-designed study established the neonatal reference range for PTH in preterm infants to be 0.9-11.9 pmol/L, whereby >12 pmol/L would be considered abnormal (Matejek et al., 2024).

On balance, it was felt that a cut-off >10 pmol/L be a pragmatic choice for PTH, especially as recent real-word data would also suggest that this is an appropriate threshold (Levene et al., 2025). It is important to note that 25-hydroxyvitamin D levels should ideally be normalised (i.e. >50 nmol/L) to ensure elevated PTH is due to MBDP alone, and not due in some part to vitamin D deficiency. It is also recognised that there is considerable method-related variation in PTH results, which will in itself, affect cut-offs (Sturgeon et al., 2017). Therefore, local audits of data are advised to establish specific cut-offs relevant to local assays.

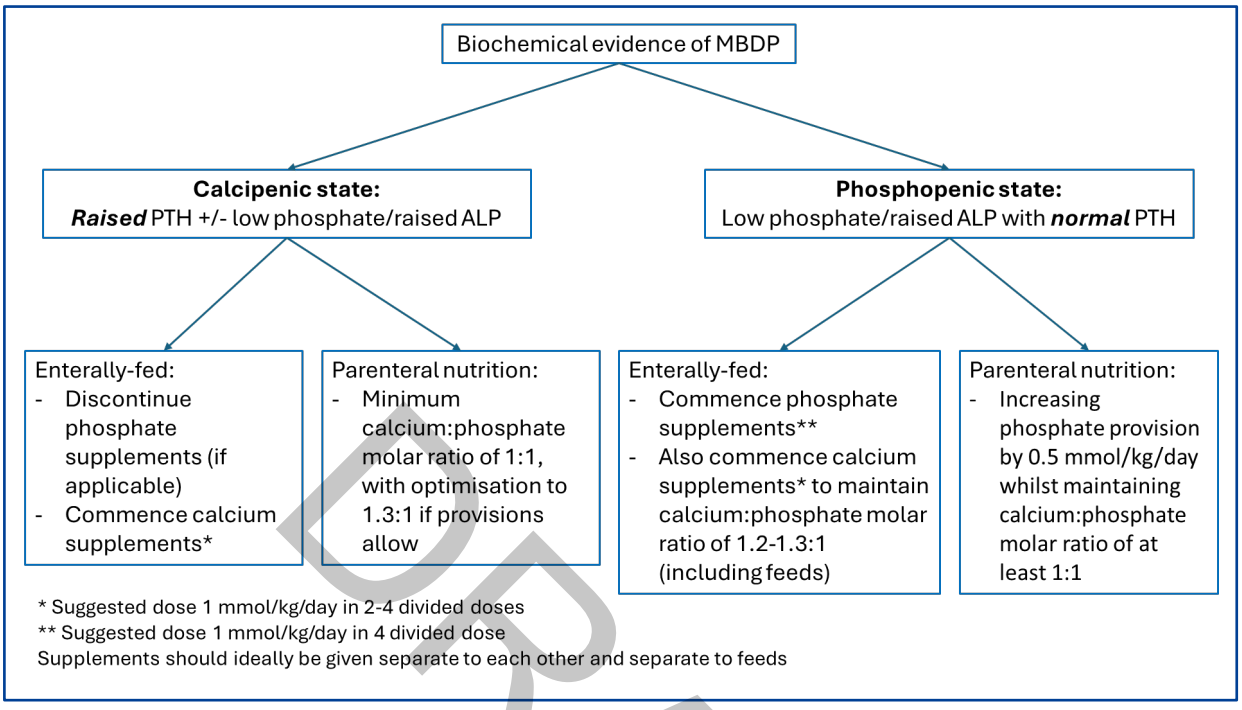
Phosphate: There is mixed evidence on whether low phosphate is predictive of MBDP and its utility as a screening tool (Abdallah et al., 2016, Backstrom et al., 2000, Czech-Kowalska et al., 2016, Faerk et al., 2002, Hung et al., 2011, Koo et al., 1982, Lee et al., 2017, Viswanathan et al., 2014). Reference ranges for phosphate vary with age and laboratory, and therefore the lower limit of a local laboratory neonatal-specific reference range should be used as a cut-off.

Current evidence does not support the routine measurement of the following biochemical parameters as part of screening in clinical practice: TmP/GFR (Czech-Kowalska et al., 2016), 25-hydroxyvitamin D (Czech-Kowalska et al., 2016, Koo et al., 1982), adjusted calcium (Abdallah et al., 2016, Backstrom et al., 2000, Czech-Kowalska et al., 2016, Hung et al., 2011, Koo et al., 1982, Lee et al., 2017, Viswanathan et al., 2014) use of imaging tools (plain radiograph, dual energy x-ray absorptiometry or quantitative ultrasound) in MBDP screening or diagnosis. However, plain radiographs undertaken for other purposes may incidentally highlight features of MBDP (including osteopenia, periosteal reaction, rickets and fractures). Osteopenia radiologically is a late marker of MBDP, apparent only evident when almost 40% reduction in bone mineral content (Mazess et al., 1984), and should not be used for screening.

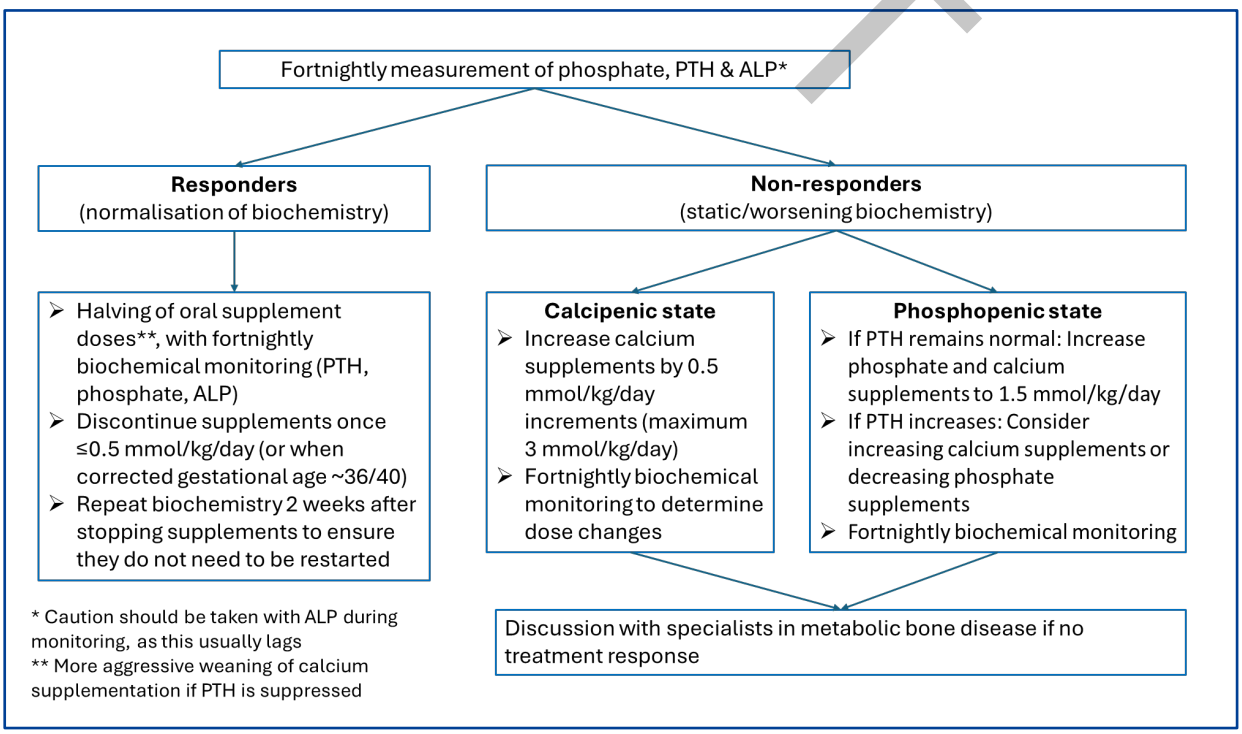
4. What treatments may be considered for MBDP and how is response monitored?

Recommendation	Evidence quality	Strength	Rationale for the recommendation
Treatment for calcipenic state (raised ALP and/or low phosphate and/or raised PTH): See Flowchart 2	**Very low**	**Consensus**	Enteral calcium supplementation is within the BNFc recommendations of 0.25-2 mmol/kg/day for calcium deficiency. Minimum PN molar ratios as per NICE, with optimised ratios to enhance calcium provision in view of secondary hyperparathyroidism, although may be difficult to achieve practically
Treatment for phosphopenic state (raised ALP and/or low phosphate with normal/low PTH): See Flowchart 2	**Very low**	**Consensus**	Concurrent phosphate and calcium supplementation is given to maintain optimal physiologic molar calcium:phosphate ratio of 1.2-1.3:1 (when enteral feeds + supplements are considered) to enable optimal absorption of both Minimum PN molar ratios as per NICE, with increase in phosphate balanced with additional calcium to maintain this ratio
Subsequent monitoring: See Flowchart 3	**Very low**	**Consensus**	Consensus-based approach
If serum 25-hydroxyvitamin D level <50 nmol/L is noted, provide a total vitamin D dose of 1000 units (50 micrograms) daily (multivitamin supplementation plus additional cholecalciferol)	**High**	**Moderate**	Evidence suggests this dose optimises vitamin D stores within 4-8 weeks, whereas lower doses take up to 3 months
Subsequent monitoring of 25-hydroxyvitamin D levels for those on treatment doses should not be more frequently than 4-6 weekly, ideally 6-12 weekly	**Very low**	**Consensus**	25-hydroxyvitamin D stores take time to achieve, therefore more frequent monitoring risks unnecessary increases in dosing

Flow chart 2: Suggested algorithm for the treatment of MBDP, depending on whether a calcipenic (elevated PTH) or phosphopenic (normal PTH) state is demonstrated, subdivided by form of nutrition.



Flow chart 3: Suggested algorithm for the monitoring of MBDP, once treatment is commenced, based on whether there is biochemical response to supplements, and subsequent dose alterations



Further information

There is a limited evidence base for the treatment of MBDP, with the literature limited to consensus-based recommendations (Chinoy et al., 2019, Forster et al., 2024, Grover et al., 2024, Yan-Mei et al., 2021). The recommendations here are informed by published literature and current practice across the UK, providing a consensus-based and pragmatic approach to the treatment of MBDP and its monitoring.

Progression to active management of MBDP assumes the following:

1. That estimated nutritional requirements are being met and have been for an adequate duration (at least 2 weeks).
2. That abnormalities in bone biochemistry exist: phosphate below the local reference range and/or an ALP > 650 IU/L and/or PTH > 10 pmol/L.

Interpretation of PTH to guide treatment

PTH stimulates bone resorption and is a measure of bone turnover. PTH levels will help determine whether there is underlying **calcium or phosphate deficiency** and guide supplementation (Chinoy et al., 2019, Czech-Kowalska et al., 2016, Levene et al., 2023, Matejek et al., 2018).

- PTH will be raised if there is **calcium (or vitamin D) deficiency, with or without raised ALP and low phosphate.**
- PTH will be low or normal if there is **phosphate deficiency, with raised ALP or low phosphate.**

A normal measured serum level can still be seen even when total body calcium levels are low, due to the actions of PTH, which will be elevated. Untreated calcium deficiency will eventually lead to low serum phosphate due to the increased PTH activity and increased bone resorption. Misinterpretation of this low phosphate in the context of untreated calcium deficiency and secondary hyperparathyroidism can result in inappropriate phosphate supplementation, which is why PTH levels are helpful in this context.

Calcipenic state

In contrast to the phosphopenic state (see below), in the calcipenic state additional phosphate supplementation is not required, as the secondary hyperparathyroidism indicates a need for calcium *additional* to this ratio. Ideally, calcium supplementation should be given in between feeds, and separate from iron supplementation, to prevent precipitation and optimise absorption (Appendix 4).

Achieving the optimal calcium:phosphate molar ratio of 1.3:1 in PN can be challenging due to solution stability limits, local PN provision, and restricted line access for side-arm infusions (Nehra et al., 2013, Mihatsch et al., 2018).

Phosphopenic state

Phosphate given alone or out of ratio can trigger secondary hyperparathyroidism and bone demineralisation (Chinoy et al., 2019). Supplementation should be divided into several doses (not just 1–2 daily as per BNFc) to reduce the risk of secondary hyperparathyroidism. Ideally, calcium and phosphate should be given between feeds, separately from each other and from iron, to prevent precipitation and optimise absorption (Appendix 4). When using standard preterm feeds (Appendix 5), this combined approach maintains the recommended physiological calcium:phosphate ratio.

Ongoing management after commencing treatment for MBDP

There is limited evidence on the optimal timing for assessing biochemical response, so consensus recommendations are provided. ALP normalises slower than PTH and phosphate and should not be used in isolation, though ALP trends are useful. In calcipenic infants, a fall in PTH toward the normal range (<10 pmol/L) indicates effective treatment, while a suppressed PTH (<1.0 pmol/L) warrants faster calcium weaning to avoid nephrocalcinosis. Ongoing treatment can be managed as an outpatient if needed, though most infants will not require this. As MBDP is transient, some units consider trial stopping supplements at term-corrected age (in the absence of ongoing risk factors), with repeat bone biochemistry 2 weeks later to confirm they are no longer needed.

Vitamin D deficiency in neonates

There is no agreed definition of vitamin D deficiency in preterm infants. Therefore, the paediatric consensus of sufficiency (25-hydroxyvitamin D >50 nmol/L) is advised (Abrams and Committee on, 2013, Embleton et al., 2023, Munns et al., 2016). Although the evidence benefit (biochemical, clinical and radiological) of optimising vitamin D in preterm infants is mixed (Abrams, 2020, Backstrom et al., 1999, Koo et al., 1989, Kumar et al., 2022, Mathur et al., 2016, McCarthy et al., 2013, Natarajan et al., 2014, Taylor et al., 2018, Yang et al., 2018), in the absence of harm, optimising 25-hydroxyvitamin D levels >50 nmol/L is advised, as per ESPGHAN (Embleton et al., 2023).

Studies that suggest treatment with 400 IU/day of cholecalciferol in preterm/LBW infants show normalisation of levels after up to 3 months (Abrams, 2020, Anderson-Berry et al., 2017, Fort et al., 2016, McCarthy et al., 2013, Munshi et al., 2018), whereas 800–1000 IU/day achieved better vitamin D levels within 4–8 weeks (Bozkurt et al., 2017, Embleton et al., 2023, Fort et al., 2016, Matejek et al., 2020, Mathilde et al., 2022, Mathur et al., 2016, Natarajan et al., 2014, Tergestina et al., 2016, Kolodziejczyk-Nowotarska et al., 2021, Aristizabal et al., 2023, Cho et al., 2017, Choudhury et al., 2021). Therefore, if vitamin D deficiency (<50 nmol/L) is present, a total of 1000 IU/day (including multivitamin content) is recommended, increasing up to 3000 IU/day if levels remain low on 6-12 weekly monitoring. If absorption is impaired, intramuscular ergocalciferol may be used. Once sufficiency is achieved, reduce to 400 IU/day (i.e. through multivitamin supplementation alone). If levels exceed 150 nmol/L, stop all supplementation for 4–6 weeks, then resume 400 IU/day thereafter.

Recommendations of this Framework

Recommendations for Networks

All services are encouraged to review their own local and network practice or guidance (where it exists) and consider whether there are elements of the BAPM framework they wish to incorporate or align to.

Recommendations for Audit

This Framework is grounded in the best available evidence; however, in several areas where evidence is lacking, recommendations have been developed through consensus. Accordingly, the working group advises auditing local practices to ensure their appropriateness for local populations and to gather supplementary data to inform future revisions of this national Framework.

Recommendations for Research

This Framework has highlighted the significant deficits in evidence base in this field, and therefore the importance of future research focussed on MBDP, establishing data to support evidence-based recommendations in the future relating to optimal screening, preventative and treatment approaches, as well as evidence of long-term outcomes.

The following have been suggested by the working group as aspects of MBDP that require clarification with future studies:

- Timing and frequency of MBDP screening informed by epidemiological studies that have delineated when biochemical derangements begin to occur in a large cohort of preterm infants, stratified by birth weight and birth gestation.
- Optimal cut-offs for biochemical screening markers, particularly for PTH and vitamin D in preterm infants.
- Aetiology of the phosphopenic state to determine whether phosphopenia is due to dietary deficiencies or due to renal phosphate wasting.
- Further association/correlation studies to establish more firmly whether medications such as caffeine, furosemide and proton pump inhibitors are truly risk factors for the development of MBDP.
- Optimal enteral treatment regimens which is currently largely consensus-based due to the absence of evidence. Large multi-centre prospective trials that use various doses and ratios with appropriate monitoring are needed to establish an evidence base.
- Role of vitamin D in preterm bone mineralisation. There remains a lack of clarity on the importance of vitamin D specifically for preterm infants, where it is hypothesised that mineral absorption is largely passive.
- Short-term and long-term outcomes of MBDP including rates of fractures and bone density data.
- The role of physical activity regimens on preterm bone health (strength and mineralisation), and prevention and treatment of MBDP. Some of these studies are ongoing internationally, but need to robustly examine not just bone density and bone turnover data, but also more clinically useful outcomes such as changes in bone biochemistry (ALP, PTH and phosphate – which is currently used to guide treatment) and in fracture rates.
- The development of a risk stratification tool to inform optimal handling and positioning to minimise the risk of fractures in the most severe cases.

References

1991. Dietary reference values for food energy and nutrients for the United Kingdom. Report of the Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy. *Rep Health Soc Subj (Lond),* 41**,** 1-210.
ABDALLAH, E. A. A., SAID, R. N., MOSALLAM, D. S., MOAWAD, E. M. I., KAMAL, N. M. & FATHALLAH, M. G. E. 2016. Serial serum alkaline phosphatase as an early biomarker for osteopenia of prematurity. *Medicine (Baltimore),* 95**,** e4837.
ABRAMS, S. A. 2020. Vitamin D in Preterm and Full-Term Infants. *Ann Nutr Metab,* 76 Suppl 2**,** 6-14.
ABRAMS, S. A. & COMMITTEE ON, N. 2013. Calcium and vitamin d requirements of enterally fed preterm infants. *Pediatrics,* 131**,** e1676-83.
ADNAN, M., WU, S. Y., KHILFEH, M. & DAVIS, V. 2022. Vitamin D status in very low birth weight infants and response to vitamin D intake during their NICU stays: a prospective cohort study. *J Perinatol,* 42**,** 209-216.
ANDERSON-BERRY, A., THOENE, M., WAGNER, J., LYDEN, E., JONES, G., KAUFMANN, M., VAN ORMER, M. & HANSON, C. 2017. Randomized trial of two doses of vitamin D3 in preterm infants <32 weeks: Dose impact on achieving desired serum 25(OH)D3 in a NICU population. *PLoS One,* 12**,** e0185950.
ANDREWS, J. C., SCHUNEMANN, H. J., OXMAN, A. D., POTTIE, K., MEERPOHL, J. J., COELLO, P. A., RIND, D., MONTORI, V. M., BRITO, J. P., NORRIS, S., ELBARBARY, M., POST, P., NASSER, M., SHUKLA, V., JAESCHKE, R., BROZEK, J., DJULBEGOVIC, B. & GUYATT, G. 2013. GRADE guidelines: 15. Going from evidence to recommendation-determinants of a recommendation's direction and strength. *J Clin Epidemiol,* 66**,** 726-35.
ANGELIKA, D., UGRASENA, I. D. G., ETIKA, R., RAHARDJO, P., BOS, A. F. & SAUER, P. J. J. 2021. The incidence of osteopenia of prematurity in preterm infants without phosphate supplementation: A prospective, observational study. *Medicine (Baltimore),* 100**,** e25758.
ARISTIZABAL, N., HOLDER, M. P., DURHAM, L., ASHRAF, A. P., TAYLOR, S. & SALAS, A. A. 2023. Safety and Efficacy of Early Vitamin D Supplementation in Critically Ill Extremely Preterm Infants: An Ancillary Study of a Randomized Trial. *J Acad Nutr Diet,* 123**,** 87-94.
ARSLANOGLU, S., BOQUIEN, C. Y., KING, C., LAMIREAU, D., TONETTO, P., BARNETT, D., BERTINO, E., GAYA, A., GEBAUER, C., GROVSLIEN, A., MORO, G. E., WEAVER, G., WESOLOWSKA, A. M. & PICAUD, J. C. 2019. Fortification of Human Milk for Preterm Infants: Update and Recommendations of the European Milk Bank Association (EMBA) Working Group on Human Milk Fortification. *Front Pediatr,* 7**,** 76.
ATKINS, D., BEST, D., BRISS, P. A., ECCLES, M., FALCK-YTTER, Y., FLOTTORP, S., GUYATT, G. H., HARBOUR, R. T., HAUGH, M. C., HENRY, D., HILL, S., JAESCHKE, R., LENG, G., LIBERATI, A., MAGRINI, N., MASON, J., MIDDLETON, P., MRUKOWICZ, J., O'CONNELL, D., OXMAN, A. D., PHILLIPS, B., SCHUNEMANN, H. J., EDEJER, T., VARONEN, H., VIST, G. E., WILLIAMS, J. W., JR., ZAZA, S. & GROUP, G. W. 2004. Grading quality of evidence and strength of recommendations. *BMJ,* 328**,** 1490.
AVILA-ALVAREZ, A., URISARRI, A., FUENTES-CARBALLAL, J., MANDIA, N., SUCASAS-ALONSO, A. & COUCE, M. L. 2020. Metabolic Bone Disease of Prematurity: Risk Factors and Associated Short-Term Outcomes. *Nutrients,* 12.
BACKSTROM, M. C., KOURI, T., KUUSELA, A. L., SIEVANEN, H., KOIVISTO, A. M., IKONEN, R. S. & MAKI, M. 2000. Bone isoenzyme of serum alkaline phosphatase and serum inorganic phosphate in metabolic bone disease of prematurity. *Acta Paediatr,* 89**,** 867-73.
BACKSTROM, M. C., MAKI, R., KUUSELA, A. L., SIEVANEN, H., KOIVISTO, A. M., IKONEN, R. S., KOURI, T. & MAKI, M. 1999. Randomised controlled trial of vitamin D supplementation on bone density and biochemical indices in preterm infants. *Arch Dis Child Fetal Neonatal Ed,* 80**,** F161-6.
BELFORT, M. B., ANDERSON, P. J., NOWAK, V. A., LEE, K. J., MOLESWORTH, C., THOMPSON, D. K., DOYLE, L. W. & INDER, T. E. 2016. Breast Milk Feeding, Brain Development, and Neurocognitive

Outcomes: A 7-Year Longitudinal Study in Infants Born at Less Than 30 Weeks' Gestation. *J Pediatr,* 177**,** 133-139 e1.
BODDU, S. K. & LANKALA, R. 2022. Are we undertreating calcium deficiency in metabolic bone disease of prematurity? A case report and review. *Front Pediatr,* 10**,** 991488.
BOZKURT, O., URAS, N., SARI, F. N., ATAY, F. Y., SAHIN, S., ALKAN, A. D., CANPOLAT, F. E. & OGUZ, S. S. 2017. Multi-dose vitamin d supplementation in stable very preterm infants: Prospective randomized trial response to three different vitamin D supplementation doses. *Early Hum Dev,* 112**,** 54-59.
BRONSKY, J., CAMPOY, C., BRAEGGER, C. & NUTRITION, E. E. E. C. W. G. O. P. P. 2018. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Vitamins. *Clin Nutr,* 37**,** 2366-2378.
BROWN, J. V., LIN, L., EMBLETON, N. D., HARDING, J. E. & MCGUIRE, W. 2020. Multi-nutrient fortification of human milk for preterm infants. *Cochrane Database Syst Rev,* 6**,** CD000343.
BROWN, J. V. E., WALSH, V. & MCGUIRE, W. 2019. Formula versus maternal breast milk for feeding preterm or low birth weight infants. *Cochrane Database Syst Rev,* 8**,** CD002972.
BROWN, L. D., STREMMING, J. & ROBINSON, D. T. 2024. Targeting optimal protein delivery in parenteral and enteral nutrition for preterm infants: a review of randomized, controlled trials. *J Perinatol,* 44**,** 603-611.
CHEN, W., YANG, C., CHEN, H. & ZHANG, B. 2018. Risk factors analysis and prevention of metabolic bone disease of prematurity. *Medicine (Baltimore),* 97**,** e12861.
CHINOY, A., MUGHAL, M. Z. & PADIDELA, R. 2019. Metabolic bone disease of prematurity: causes, recognition, prevention, treatment and long-term consequences. *Arch Dis Child Fetal Neonatal Ed*.
CHINOY, A., MUGHAL, M. Z. & PADIDELA, R. 2021. Metabolic bone disease of prematurity-National survey of current neonatal and paediatric endocrine approaches. *Acta Paediatr,* 110**,** 1855-1862.
CHO, S. Y., PARK, H. K. & LEE, H. J. 2017. Efficacy and safety of early supplementation with 800 IU of vitamin D in very preterm infants followed by underlying levels of vitamin D at birth. *Ital J Pediatr,* 43**,** 45.
CHOUDHURY, K. A., KUMAR, M., TRIPATHI, S., SINGH, S. N., SINGH, K. & SINGH, V. K. 2021. Vitamin D Status of Very Low Birth Weight Neonates at Baseline and Follow-up after Daily Intake of 800 IU Vitamin D. *J Trop Pediatr,* 67.
CORPELEIJN, W. E., DE WAARD, M., CHRISTMANN, V., VAN GOUDOEVER, J. B., JANSEN-VAN DER WEIDE, M. C., KOOI, E. M., KOPER, J. F., KOUWENHOVEN, S. M., LAFEBER, H. N., MANK, E., VAN TOLEDO, L., VERMEULEN, M. J., VAN VLIET, I. & VAN ZOEREN-GROBBEN, D. 2016. Effect of Donor Milk on Severe Infections and Mortality in Very Low-Birth-Weight Infants: The Early Nutrition Study Randomized Clinical Trial. *JAMA Pediatr,* 170**,** 654-61.
CZECH-KOWALSKA, J. 2020. Mineral and nutritional requirements of preterm infant. *Semin Fetal Neonatal Med,* 25**,** 101071.
CZECH-KOWALSKA, J., CZEKUC-KRYSKIEWICZ, E., PLUDOWSKI, P., ZANIUK, K., JAWORSKI, M., LUBA, A., GRZYBOWSKA, K., PILAT, K. & DOBRZANSKA, A. 2016. The Clinical and Biochemical Predictors of Bone Mass in Preterm Infants. *PLoS One,* 11**,** e0165727.
EIDELMAN, A. I. 2012. Breastfeeding and the use of human milk: an analysis of the American Academy of Pediatrics 2012 Breastfeeding Policy Statement. *Breastfeed Med,* 7**,** 323-4.
EMBLETON, N. D., JENNIFER MOLTU, S., LAPILLONNE, A., VAN DEN AKKER, C. H. P., CARNIELLI, V., FUSCH, C., GERASIMIDIS, K., VAN GOUDOEVER, J. B., HAIDEN, N., IACOBELLI, S., JOHNSON, M. J., MEYER, S., MIHATSCH, W., DE PIPAON, M. S., RIGO, J., ZACHARIASSEN, G., BRONSKY, J., INDRIO, F., KOGLMEIER, J., DE KONING, B., NORSA, L., VERDUCI, E. & DOMELLOF, M. 2023. Enteral Nutrition in Preterm Infants (2022): A Position Paper From the ESPGHAN Committee on Nutrition and Invited Experts. *J Pediatr Gastroenterol Nutr,* 76**,** 248-268.
EMBLETON, N. D. & VAN DEN AKKER, C. H. P. 2019. Protein intakes to optimize outcomes for preterm infants. *Semin Perinatol,* 43**,** 151154.
FAERK, J., PEITERSEN, B., PETERSEN, S. & MICHAELSEN, K. F. 2002. Bone mineralisation in premature

infants cannot be predicted from serum alkaline phosphatase or serum phosphate. *Arch Dis Child Fetal Neonatal Ed,* 87**,** F133-6.
FERRARI, F., BERTONCELLI, N., GALLO, C., ROVERSI, M. F., GUERRA, M. P., RANZI, A. & HADDERS-ALGRA, M. 2007. Posture and movement in healthy preterm infants in supine position in and outside the nest. *Arch Dis Child Fetal Neonatal Ed,* 92**,** F386-90.
FEWTRELL, M. S., COLE, T. J., BISHOP, N. J. & LUCAS, A. 2000. Neonatal factors predicting childhood height in preterm infants: evidence for a persisting effect of early metabolic bone disease? *J Pediatr,* 137**,** 668-73.
FIGUERAS-ALOY, J., ALVAREZ-DOMINGUEZ, E., PEREZ-FERNANDEZ, J. M., MORETONES-SUNOL, G., VIDAL-SICART, S. & BOTET-MUSSONS, F. 2014. Metabolic bone disease and bone mineral density in very preterm infants. *J Pediatr,* 164**,** 499-504.
FORSTER, C., HOODBHOY, S., MACDOUGALL, C., KING, K., GOODING, N., MAK, K. & MUSHTAQ, T. 2024. Practical approach to managing metabolic bone disease of prematurity in the neonatal unit. *Arch Dis Child Educ Pract Ed,* 109**,** 143-146.
FORT, P., SALAS, A. A., NICOLA, T., CRAIG, C. M., CARLO, W. A. & AMBALAVANAN, N. 2016. A Comparison of 3 Vitamin D Dosing Regimens in Extremely Preterm Infants: A Randomized Controlled Trial. *J Pediatr,* 174**,** 132-138 e1.
GROVER, M., ASHRAF, A. P., BOWDEN, S. A., CALABRIA, A., DIAZ-THOMAS, A., KRISHNAN, S., MILLER, J. L., ROBINSON, M. E. & DIMEGLIO, L. A. 2024. Invited Mini Review Metabolic Bone Disease of Prematurity: Overview and Practice Recommendations. *Horm Res Paediatr*.
HARRISON, C. M., JOHNSON, K. & MCKECHNIE, E. 2008. Osteopenia of prematurity: a national survey and review of practice. *Acta Paediatr,* 97**,** 407-13.
HOGBERG, U., ANDERSSON, J., HOGBERG, G. & THIBLIN, I. 2018. Metabolic bone disease risk factors strongly contributing to long bone and rib fractures during early infancy: A population register study. *PLoS One,* 13**,** e0208033.
HUNG, Y. L., CHEN, P. C., JENG, S. F., HSIEH, C. J., PENG, S. S., YEN, R. F., CHOU, H. C., CHEN, C. Y., TSAO, P. N. & HSIEH, W. S. 2011. Serial measurements of serum alkaline phosphatase for early prediction of osteopaenia in preterm infants. *J Paediatr Child Health,* 47**,** 134-9.
JENSEN, E. A., WHITE, A. M., LIU, P., YEE, K., WABER, B., MONK, H. M. & ZHANG, H. 2016. Determinants of Severe Metabolic Bone Disease in Very Low-Birth-Weight Infants with Severe Bronchopulmonary Dysplasia Admitted to a Tertiary Referral Center. *Am J Perinatol,* 33**,** 107-13.
KAVURT, S., DEMIREL, N., YUCEL, H., UNAL, S., YILDIZ, Y. T. & BAS, A. Y. 2021. Evaluation of radiologic evidence of metabolic bone disease in very low birth weight infants at fourth week of life. *J Perinatol,* 41**,** 2668-2673.
KOLODZIEJCZYK-NOWOTARSKA, A., BOKINIEC, R. & SELIGA-SIWECKA, J. 2021. Monitored Supplementation of Vitamin D in Preterm Infants: A Randomized Controlled Trial. *Nutrients,* 13.
KOO, W. W., GUPTA, J. M., NAYANAR, V. V., WILKINSON, M. & POSEN, S. 1982. Skeletal changes in preterm infants. *Arch Dis Child,* 57**,** 447-52.
KOO, W. W., SHERMAN, R., SUCCOP, P., HO, M., BUCKLEY, D. & TSANG, R. C. 1989. Serum vitamin D metabolites in very low birth weight infants with and without rickets and fractures. *J Pediatr,* 114**,** 1017-22.
KUMAR, M., SHAIKH, S., SINHA, B., UPADHYAY, R. P., CHOUDHARY, T. S., CHANDOLA, T. R., MAZUMDER, S., TANEJA, S., BHANDARI, N. & CHOWDHURY, R. 2022. Enteral Vitamin D Supplementation in Preterm or Low Birth Weight Infants: A Systematic Review and Meta-analysis. *Pediatrics,* 150.
LEE, J., PARK, H. K., KIM, J. H., CHOI, Y. Y. & LEE, H. J. 2017. Bone Mineral Density According to Dual Energy X-ray Absorptiometry is Associated with Serial Serum Alkaline Phosphatase Level in Extremely Low Birth Weight Infants at Discharge. *Pediatr Neonatol,* 58**,** 251-257.
LEVENE, I., DHAMI, A., MORENO, M., SHINE, B., CHINOY, A., PADIDELA, R. & MOLNAR, Z. 2023. Characterisation of parathyroid hormone concentration in extremely preterm or very low birthweight infants in routine clinical screening for metabolic bone disease: A service evaluation

cohort study. *J Paediatr Child Health,* 59**,** 1140-1145.
LEVENE, I., MORENO, M., SHINE, B., CHINOY, A., PADIDELA, R. & MOLNAR, Z. 2025. Markers of Metabolic Bone Disease in Extremely Preterm and Very Low Birth Weight Infants: A Four-Part Cohort Study Spanning Changes in Clinical Approach. *J Paediatr Child Health,* 61**,** 1477-1485.
LU, K. L., XIE, S. S., HU, Q., YANG, Z. Y., FAN, Q. L., LIU, E. & ZHANG, Y. P. 2023. Diagnostic markers of metabolic bone disease of prematurity in preterm infants. *Bone,* 169**,** 116656.
LUCAS-HERALD, A., BUTLER, S., MACTIER, H., MCDEVITT, H., YOUNG, D. & AHMED, S. F. 2012. Prevalence and characteristics of rib fractures in ex-preterm infants. *Pediatrics,* 130**,** 1116-9.
LUCAS, A., BROOKE, O. G., BAKER, B. A., BISHOP, N. & MORLEY, R. 1989. High alkaline phosphatase activity and growth in preterm neonates. *Arch Dis Child,* 64**,** 902-9.
LYON, A. J., MCINTOSH, N., WHEELER, K. & WILLIAMS, J. E. 1987. Radiological rickets in extremely low birthweight infants. *Pediatr Radiol,* 17**,** 56-8.
MASTROENI, S. S., OKADA, I. A., RONDO, P. H., DURAN, M. C., PAIVA, A. A. & NETO, J. M. 2006. Concentrations of Fe, K, Na, Ca, P, Zn and Mg in maternal colostrum and mature milk. *J Trop Pediatr,* 52**,** 272-5.
MATEJEK, T., NAVRATILOVA, M., ZALOUDKOVA, L., MALAKOVA, J., MALY, J., SKALOVA, S. & PALICKA, V. 2018. Parathyroid hormone - reference values and association with other bone metabolism markers in very low birth weight infants - pilot study. *J Matern Fetal Neonatal Med***,** 1-8.
MATEJEK, T., NAVRATILOVA, M., ZALOUDKOVA, L., MALAKOVA, J., MALY, J., SKALOVA, S. & PALICKA, V. 2020. Vitamin D status of very low birth weight infants at birth and the effects of generally recommended supplementation on their vitamin D levels at discharge. *J Matern Fetal Neonatal Med,* 33**,** 3784-3790.
MATEJEK, T., ZAPLETALOVA, B., STRANIK, J., ZALOUDKOVA, L. & PALICKA, V. 2024. Reference values of parathyroid hormone in very low birth weight infants. *Ann Clin Biochem***,** 45632241245942.
MATHILDE, M., BUTIN, M., PASCAL, R., PLAISANT, F., LABORIE, S. & BACCHETTA, J. 2022. Local protocol helped to deliver vitamin D levels more accurately in preterm infants. *Acta Paediatr,* 111**,** 76-85.
MATHUR, N. B., SAINI, A. & MISHRA, T. K. 2016. Assessment of Adequacy of Supplementation of Vitamin D in Very Low Birth Weight Preterm Neonates: A Randomized Controlled Trial. *J Trop Pediatr,* 62**,** 429-435.
MAZESS, R. B., PEPPLER, W. W., CHESNEY, R. W., LANGE, T. A., LINDGREN, U. & SMITH, E., JR. 1984. Does bone measurement on the radius indicate skeletal status? Concise communication. *J Nucl Med,* 25**,** 281-8.
MCCARTHY, R. A., MCKENNA, M. J., OYEFESO, O., UDUMA, O., MURRAY, B. F., BRADY, J. J., KILBANE, M. T., MURPHY, J. F., TWOMEY, A., CP, O. D., MURPHY, N. P. & MOLLOY, E. J. 2013. Vitamin D nutritional status in preterm infants and response to supplementation. *Br J Nutr,* 110**,** 156-63.
MEINZEN-DERR, J., POINDEXTER, B., WRAGE, L., MORROW, A. L., STOLL, B. & DONOVAN, E. F. 2009. Role of human milk in extremely low birth weight infants' risk of necrotizing enterocolitis or death. *J Perinatol,* 29**,** 57-62.
MIHATSCH, W., FEWTRELL, M., GOULET, O., MOLGAARD, C., PICAUD, J. C., SENTERRE, T. & NUTRITION, E. E. E. C. W. G. O. P. P. 2018. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Calcium, phosphorus and magnesium. *Clin Nutr,* 37**,** 2360-2365.
MILLER, J., TONKIN, E., DAMARELL, R. A., MCPHEE, A. J., SUGANUMA, M., SUGANUMA, H., MIDDLETON, P. F., MAKRIDES, M. & COLLINS, C. T. 2018. A Systematic Review and Meta-Analysis of Human Milk Feeding and Morbidity in Very Low Birth Weight Infants. *Nutrients,* 10.
MITCHELL, S. M., ROGERS, S. P., HICKS, P. D., HAWTHORNE, K. M., PARKER, B. R. & ABRAMS, S. A. 2009. High frequencies of elevated alkaline phosphatase activity and rickets exist in extremely low birth weight infants despite current nutritional support. *BMC Pediatr,* 9**,** 47.
MOREIRA, A., SWISCHUK, L., MALLOY, M., MUDD, D., BLANCO, C. & GEARY, C. 2014. Parathyroid hormone as a marker for metabolic bone disease of prematurity. *J Perinatol,* 34**,** 787-91.
MUNNS, C. F., SHAW, N., KIELY, M., SPECKER, B. L., THACHER, T. D., OZONO, K., MICHIGAMI, T.,

TIOSANO, D., MUGHAL, M. Z., MAKITIE, O., RAMOS-ABAD, L., WARD, L., DIMEGLIO, L. A., ATAPATTU, N., CASSINELLI, H., BRAEGGER, C., PETTIFOR, J. M., SETH, A., IDRIS, H. W., BHATIA, V., FU, J., GOLDBERG, G., SAVENDAHL, L., KHADGAWAT, R., PLUDOWSKI, P., MADDOCK, J., HYPPONEN, E., ODUWOLE, A., FREW, E., AGUIAR, M., TULCHINSKY, T., BUTLER, G. & HOGLER, W. 2016. Global Consensus Recommendations on Prevention and Management of Nutritional Rickets. *J Clin Endocrinol Metab,* 101**,** 394-415.
MUNSHI, U. K., GRAZIANO, P. D., MEUNIER, K., LUDKE, J. & RIOS, A. 2018. Serum 25 Hydroxy Vitamin D Levels in Very Low Birth Weight Infants Receiving Oral Vitamin D Supplementation. *J Pediatr Gastroenterol Nutr,* 66**,** 676-679.
MUTLU, M., AKTURK-ACAR, F., KADER, S., ASLAN, Y. & KARAGUZEL, G. 2023. Risk Factors and Clinical Characteristics of Metabolic Bone Disease of Prematurity. *Am J Perinatol,* 40**,** 519-524.
NATARAJAN, C. K., SANKAR, M. J., AGARWAL, R., PRATAP, O. T., JAIN, V., GUPTA, N., GUPTA, A. K., DEORARI, A. K., PAUL, V. K. & SREENIVAS, V. 2014. Trial of daily vitamin D supplementation in preterm infants. *Pediatrics,* 133**,** e628-34.
NEHRA, D., CARLSON, S. J., FALLON, E. M., KALISH, B., POTEMKIN, A. K., GURA, K. M., SIMPSER, E., COMPHER, C., PUDER, M., AMERICAN SOCIETY FOR, P. & ENTERAL, N. 2013. A.S.P.E.N. clinical guidelines: nutrition support of neonatal patients at risk for metabolic bone disease. *JPEN J Parenter Enteral Nutr,* 37**,** 570-98.
PATEL, A. L., JOHNSON, T. J., ENGSTROM, J. L., FOGG, L. F., JEGIER, B. J., BIGGER, H. R. & MEIER, P. P. 2013. Impact of early human milk on sepsis and health-care costs in very low birth weight infants. *J Perinatol,* 33**,** 514-9.
PEREIRA-DA-SILVA, L., COSTA, A., PEREIRA, L., FILIPE, A., VIRELLA, D., LEAL, E., MOREIRA, A., ROSA, M., MENDES, L. & SERELHA, M. 2011. Early high calcium and phosphorus intake by parenteral nutrition prevents short-term bone strength decline in preterm infants. *J Pediatr Gastroenterol Nutr,* 52**,** 203-9.
PERRONE, M., CASIRATI, A., STAGI, S., AMATO, O., PIEMONTESE, P., LIOTTO, N., ORSI, A., MENIS, C., PESENTI, N., TABASSO, C., ROGGERO, P. & MOSCA, F. 2022. Don't Forget the Bones: Incidence and Risk Factors of Metabolic Bone Disease in a Cohort of Preterm Infants. *Int J Mol Sci,* 23.
QUIGLEY, M., EMBLETON, N. D. & MCGUIRE, W. 2019. Formula versus donor breast milk for feeding preterm or low birth weight infants. *Cochrane Database Syst Rev,* 7**,** CD002971.
RAUCH, F. & SCHOENAU, E. 2002. Skeletal development in premature infants: a review of bone physiology beyond nutritional aspects. *Arch Dis Child Fetal Neonatal Ed,* 86**,** F82-5.
RAYANNAVAR, A. & CALABRIA, A. C. 2020. Screening for Metabolic Bone Disease of prematurity. *Semin Fetal Neonatal Med,* 25**,** 101086.
RIGO, J., NYAMUGABO, K., PICAUD, J. C., GERARD, P., PIELTAIN, C. & DE CURTIS, M. 1998. Reference values of body composition obtained by dual energy X-ray absorptiometry in preterm and term neonates. *J Pediatr Gastroenterol Nutr,* 27**,** 184-90.
ROIG, M. J. A., A.; BARBERA, R.; FARRE, R.; LAGARDA, M. J. 1999. Calcium bioavailability in human milk, cow milk and infant formulas—Comparison between dialysis and solubility methods. *Food Chemistry,* 65**,** 353-357.
SCHULZKE, S. M., KAEMPFEN, S., TRACHSEL, D. & PATOLE, S. K. 2014. Physical activity programs for promoting bone mineralization and growth in preterm infants. *Cochrane Database Syst Rev***,** CD005387.
STALNAKER, K. A. & POSKEY, G. A. 2016. Osteopenia of Prematurity: Does Physical Activity Improve Bone Mineralization in Preterm Infants? *Neonatal Netw,* 35**,** 95-104.
STURGEON, C. M., SPRAGUE, S., ALMOND, A., CAVALIER, E., FRASER, W. D., ALGECIRAS-SCHIMNICH, A., SINGH, R., SOUBERBIELLE, J. C., VESPER, H. W. & PTH, I. W. G. F. 2017. Perspective and priorities for improvement of parathyroid hormone (PTH) measurement - A view from the IFCC Working Group for PTH. *Clin Chim Acta,* 467**,** 42-47.
TAYLOR, S. N., FENTON, T. R., GROH-WARGO, S., GURA, K., MARTIN, C. R., GRIFFIN, I. J., ROZGA, M. & MOLONEY, L. 2021. Exclusive Maternal Milk Compared With Exclusive Formula on Growth and

Health Outcomes in Very-Low-Birthweight Preterm Infants: Phase II of the Pre-B Project and an Evidence Analysis Center Systematic Review. *Front Pediatr,* 9**,** 793311.
TAYLOR, S. N., WAHLQUIST, A., WAGNER, C. L., RAMAKRISHNAN, V., EBELING, M. & HOLLIS, B. W. 2018. Functional indicators of vitamin D adequacy for very low birth weight infants. *J Perinatol,* 38**,** 550-556.
TERGESTINA, M., JOSE, A., SRIDHAR, S., JOB, V., REBEKAH, G., KURUVILLA, K. A. & THOMAS, N. 2014. Vitamin D status and adequacy of standard supplementation in preterm neonates from South India. *J Pediatr Gastroenterol Nutr,* 58**,** 661-5.
TERGESTINA, M., REBEKAH, G., JOB, V., SIMON, A. & THOMAS, N. 2016. A randomized double-blind controlled trial comparing two regimens of vitamin D supplementation in preterm neonates. *J Perinatol,* 36**,** 763-7.
TKACH, E. K., WHITE, A. M., DYSART, K. C., WABER, B., NAWAB, U. S., ZHANG, H. & JENSEN, E. A. 2017. Comparison of Intact Parathyroid Hormone, Alkaline Phosphatase, Phosphate Levels for Diagnosing Severe Metabolic Bone Disease in Infants with Severe Bronchopulmonary Dysplasia. *Am J Perinatol,* 34**,** 1199-1204.
TOMLINSON, C., MCDEVITT, H., AHMED, S. F. & WHITE, M. P. 2006. Longitudinal changes in bone health as assessed by the speed of sound in very low birth weight preterm infants. *J Pediatr,* 148**,** 450-5.
TONG, L., GOPAL-KOTHANDAPANI, J. S. & OFFIAH, A. C. 2018. Feasibility of quantitative ultrasonography for the detection of metabolic bone disease in preterm infants - systematic review. *Pediatr Radiol*.
TORRO-FERRERO, G., FERNANDEZ-REGO, F. J. & GOMEZ-CONESA, A. 2021. Physical Therapy to Prevent Osteopenia in Preterm Infants: A Systematic Review. *Children (Basel),* 8.
TORRO-FERRERO, G., FERNANDEZ-REGO, F. J., JIMENEZ-LIRIA, M. R., AGUERA-ARENAS, J. J., PINERO-PENALVER, J., SANCHEZ-JOYA, M. D. M., FERNANDEZ-BERENGUER, M. J., RODRIGUEZ-PEREZ, M. & GOMEZ-CONESA, A. 2022. Effect of physical therapy on bone remodelling in preterm infants: a multicenter randomized controlled clinical trial. *BMC Pediatr,* 22**,** 362.
UKARAPONG, S., VENKATARAYAPPA, S. K. B., NAVARRETE, C. & BERKOVITZ, G. 2017. Risk factors of metabolic bone disease of prematurity. *Early Hum Dev,* 112**,** 29-34.
VALVERDE, R., DINERSTEIN, N. A. & VAIN, N. 2021. Mother's Own Milk and Donor Milk. *World Rev Nutr Diet,* 122**,** 212-224.
VAN GOUDOEVER, J. B., CARNIELLI, V., DARMAUN, D., SAINZ DE PIPAON, M. & NUTRITION, E. E. E. C. W. G. O. P. P. 2018. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Amino acids. *Clin Nutr,* 37**,** 2315-2323.
VISWANATHAN, S., KHASAWNEH, W., MCNELIS, K., DYKSTRA, C., AMSTADT, R., SUPER, D. M., GROH-WARGO, S. & KUMAR, D. 2014. Metabolic bone disease: a continued challenge in extremely low birth weight infants. *JPEN J Parenter Enteral Nutr,* 38**,** 982-90.
VOHR, B. R., POINDEXTER, B. B., DUSICK, A. M., MCKINLEY, L. T., HIGGINS, R. D., LANGER, J. C., POOLE, W. K., NATIONAL INSTITUTE OF CHILD, H. & HUMAN DEVELOPMENT NATIONAL RESEARCH, N. 2007. Persistent beneficial effects of breast milk ingested in the neonatal intensive care unit on outcomes of extremely low birth weight infants at 30 months of age. *Pediatrics,* 120**,** e953-9.
WANG, J., ZHAO, Q., CHEN, B., SUN, J., HUANG, J., MENG, J., LI, S., YAN, W., REN, C. & HAO, L. 2022. Risk factors for metabolic bone disease of prematurity: A meta-analysis. *PLoS One,* 17**,** e0269180.
YAN-MEI, C., XIN-ZHU, L., RONG, Z., XI-HONG, L., XIAO-MEI, T., PING-YANG, C., ZHI-CHUN, F., NUTRITIONAL COMMITTEE OF NEONATOLOGY BRANCH OF CHINESE MEDICAL DOCTOR, A., NEONATAL, N., HEALTH MANAGEMENT GROUP, P. C. O. C. H. C. M. D. A. & EDITORIAL COMMITTEE OF CHINESE JOURNAL OF CONTEMPORARY, P. 2021. Expert consensus on clinical management of metabolic bone disease of prematurity (2021). *Zhongguo Dang Dai Er Ke Za Zhi,* 23**,** 761-772.
YANG, Y., LI, Z., YAN, G., JIE, Q. & RUI, C. 2018. Effect of different doses of vitamin D supplementation on preterm infants - an updated meta-analysis. *J Matern Fetal Neonatal Med,* 31**,** 3065-3074.

YOU, S. K., LEE, J. E., LEE, S. M. & CHO, H. H. 2017. Metabolic bone disease in preterm infants: Relationship between radiologic grading in the wrist and serum biochemical markers. *Diagn Interv Imaging,* 98**,** 785-791.
ZUNG, A., TOPF-OLIVESTONE, C., SHINWELL, E. S., HOFI, L., JUSTER-REICHER, A. & FLIDEL-RIMON, O. 2020. Reassessing vitamin D supplementation in preterm infants: a prospective study and review of the literature. *J Pediatr Endocrinol Metab,* 33**,** 1273-1281.

Appendix 1: Explanation of grades and evidence levels

The GRADE (Grading of Recommendations, Assessment, Development and Evaluation) system is a transparent and systematic approach that involves assessment of two elements of the recommendation: i) the *certainty* or quality of evidence ii) *strength* of the recommendation (Atkins et al., 2004, Andrews et al., 2013). GRADE is a system developed by an international working group for rating the quality of evidence across outcomes in systematic reviews and guidelines; it can also be used to grade the strength of recommendations in guidelines. The system is designed for reviews and guidelines that examine alternative management strategies or interventions, and these may include no intervention or current best management. GRADE rates the quality of evidence for a particular outcome or recommendation of practice across studies and does not rate the quality of individual studies.

i. **Quality of evidence** reflects confidence in an effect estimate, assessing study design, bias, consistency, etc.

Quality of Evidence (Confidence in Effect)

- **High:** Further research unlikely to change the recommendation.
- **Moderate:** Further research may significantly impact confidence.
- **Low:** Further research likely to change the recommendation.
- **Very Low:** Estimate of effect is very uncertain.

What it is: How sure we are about the true effect (benefit/harm) of an intervention.

How it's assessed: Evidence from randomized controlled trials (RCTs) *starts* as "high quality" and can be downgraded, while observational studies *start* as "low quality" and can be upgraded. Starts high (e.g., Randomized Controlled Trials) and can be downgraded for risk of *bias, inconsistency, indirectness, imprecision, or publication bias;* observational studies start low and can be upgraded.

ii. **Strength of recommendation** (Strong/Weak) is the ultimate advice, determined by evidence quality *plus* other factors like benefits/harms balance, costs, and patient values, meaning high-quality evidence doesn't *always* mean a strong recommendation, nor does low-quality evidence always lead to a weak one.

Factors to consider in developing Recommendations: considers multiple factors beyond just the evidence quality when making recommendations, including the balance of benefits vs. harms, patient values/preferences, and resource considerations.

Strength of Recommendation levels:

- Strong (most patients should do it) or
- Weak (clinicians should consider context).
- Consensus * by the working group

How it's determined: A decision-making process that considers:

- **Evidence Quality:** Higher quality generally favours stronger recommendations.
- **Balance of Effects:** Clear benefits over harms (Strong) vs. close balance (Weak).
- **Patient Values & Preferences:** Consistency and importance to patients.
- **Resource Use/Costs:** Low cost/resource use favours Strong.

Appendix 2: Literature review

Articles reviewed for each individual question

Review question	References of articles
What are the risk factors for developing MBDP?	(Avila-Alvarez et al., 2020, Chen et al., 2018, Figueras-Aloy et al., 2014, Hogberg et al., 2018, Jensen et al., 2016, Mutlu et al., 2023, Nehra et al., 2013, Perrone et al., 2022, Ukarapong et al., 2017, Wang et al., 2022)
How can enteral nutrition be optimised?	(Abrams and Committee on, 2013, Brown et al., 2020, Embleton et al., 2023, Nehra et al., 2013)
How can parenteral nutrition be optimised?	(Mihatsch et al., 2018, Nehra et al., 2013, Pereira-da-Silva et al., 2011)
How can vitamin D be optimised?	(Abrams and Committee on, 2013, Bronsky et al., 2018, Chen et al., 2018, Embleton et al., 2023, Kumar et al., 2022, Levene et al., 2023, Nehra et al., 2013)
How can handling and positioning be optimised?	(Ferrari et al., 2007, Schulzke et al., 2014, Stalnaker and Poskey, 2016, Torro-Ferrero et al., 2021, Torro-Ferrero et al., 2022)
What postnatal age to start screening?	(1991, Hung et al., 2011, Lee et al., 2017)
How frequently should screening occur?	No original articles found, only consensus statements
What is the utility and cut-off for ALP in screening for MBDP?	(Abdallah et al., 2016, Backstrom et al., 2000, Czech-Kowalska et al., 2016, Faerk et al., 2002, Hung et al., 2011, Koo et al., 1982, Lee et al., 2017, Lu et al., 2023, Mitchell et al., 2009, Moreira et al., 2014, Tkach et al., 2017, Viswanathan et al., 2014)
What is the utility and cut-off for phosphate in screening for MBDP	(Abdallah et al., 2016, Backstrom et al., 2000, Czech-Kowalska et al., 2016, Faerk et al., 2002, Hung et al., 2011, Koo et al., 1982, Lee et al., 2017, Viswanathan et al., 2014)
What is the utility and cut-off for PTH in screening for MBDP?	(1991, Czech-Kowalska et al., 2016, Koo et al., 1982, Levene et al., 2023, Matejek et al., 2018, Matejek et al., 2024, Moreira et al., 2014, Tkach et al., 2017)
What is the utility and cut-off for TmP/GFR in screening for MBDP?	(Czech-Kowalska et al., 2016)
What is the utility and cut-off for 25-hydroxyvitamin D in screening for MBDP?	(Czech-Kowalska et al., 2016, Koo et al., 1982)
What is the utility and cut-off for adjusted calcium in screening for MBDP?	(Abdallah et al., 2016, Backstrom et al., 2000, Czech-Kowalska et al., 2016, Hung et al., 2011, Koo et al., 1982, Lee et al., 2017, Viswanathan et al., 2014)
What is the utility of a combination of these biochemical markers in screening for MBDP?	(1991, Backstrom et al., 2000, Figueras-Aloy et al., 2014, Moreira et al., 2014)
Is there a role for radiographs in screening for MBDP?	(Kavurt et al., 2021, You et al., 2017)
Is there a role for bone mineral density scans in screening for MBDP?	(Faerk et al., 2002, Figueras-Aloy et al., 2014, Lee et al., 2017, Rigo et al., 1998)
Is there a role for quantitative ultrasound scans in screening for MBDP?	(Tomlinson et al., 2006, Tong et al., 2018)

What is the optimal enteral treatment of MBDP?	No original articles found, only consensus statements
What is the optimal parenteral regime to treat MBDP?	No original articles found, only consensus statements
What investigations should be undertaken to monitor treatment of MBDP?	No original articles found, only consensus statements
How often should monitoring occur?	No original articles found, only consensus statements
What cut-off defines vitamin D deficiency?	(Taylor et al., 2018)
How should vitamin D deficiency be treated?	(Adnan et al., 2022, Anderson-Berry et al., 2017, Aristizabal et al., 2023, Bozkurt et al., 2017, Cho et al., 2017, Choudhury et al., 2021, Fort et al., 2016, Kolodziejczyk-Nowotarska et al., 2021, Kumar et al., 2022, Matejek et al., 2020, Mathilde et al., 2022, Mathur et al., 2016, McCarthy et al., 2013, Munshi et al., 2018, Natarajan et al., 2014, Tergestina et al., 2014, Tergestina et al., 2016, Yang et al., 2018, Zung et al., 2020)

Appendix 3: Calcium and phosphate content of enteral feeds commonly used on the neonatal unit

Feed	Calcium content per 100ml of feed (mmol)	Calcium content in 150ml/kg/day feed (mmol)	Phosphate content per 100ml of feed (mmol)	Phosphate content in 150ml/kg/day feed (mmol)	Ratio of calcium to phosphate (mmol:mmol)
Human milk (mature)*	0.85	1.28	0.48	0.72	1.8:1
Fortified breast milk (Nutriprem)	2.32	3.48	1.71	2.57	1.4:1
Fortified breast milk (Gold Prem)	2.75	4.13	1.90	2.85	1.4:1
Nutriprem 1	2.5	3.75	2.03	3.05	1.2:1
Nutriprem 2 powder	2.10	3.15	1.50	2.25	1.4:1
Gold Prem 1	2.98	4.47	2.52	3.78	1.2:1
Gold Prem 2 powder	2.05	3.08	1.61	2.42	1.3:1
Hydrolysed Nutriprem	2.45	3.68	1.74	2.61	1.4:1

*Mature expressed breast milk: McCance RA, Widdowson EM, Institute Of Food Research (Great Britain, Public Health England, Society R. McCance and Widdowson's the composition of foods. Cambridge: Royal Society of Chemistry; 2015.
Molar mass of calcium = 40g/mol
Molar mass of Phosphate = 30.1g/mol

Appendix 4: Optimising absorption of enteral supplements (both calcium and phosphate): practical dosing suggestions

Fundamentals

- Enteral supplements of calcium and phosphate should be given as minimum of 2 to an optimal of 4 divided doses over a 24 hour period. Enteral supplements of phosphate should be given as a minimum of 4 divided doses over a 24 hour period.
- Calcium and phosphate should not be given together.
- Calcium and phosphate should not be given alongside an enteral feed. Ideally these should be given between a feed.
- Calcium and phosphate should not be given alongside enteral iron.

Practicalities

Include nursing staff and parents when prescribing enteral calcium and phosphate supplements so that they can be timed appropriately and in a manner that optimises absorption.

NG-fed infants: Bolus feeds. Divide the oral supplements ideally 4 times a day and between (not with) enteral feeds or enteral iron.

NG/NJ-fed infants: Continuous feeds. Consider a pause in feeds of 1 hr every 4-6 hours. This will allow for a period of time in which enteral phosphate and/or calcium can be given in order to aid absorption. Ensure that total feed volume is not reduced if this happens, the rate should calculated over the reduced number of hours.

Responsive fed infants: breast or bottle. Consider the timings of doses in order to coincide with periods where the baby is not usually feeding. If this is impractical give the oral supplements around 30 minutes after a feed and divided as above.

Appendix 5: A supplementation approach

With supplementation of phosphate and calcium (in the phosphopenic state), the following molar calcium:phosphate ratios are achieved when enteral feeds are also considered.

Feed	Molar calcium to phosphate ratio (150ml/kg/day feed plus 1mmol/kg/day of calcium* and phosphate)
Fortified breast milk (Nutriprem)	1.3:1
Fortified breast Milk (Gold Prem)	1.3:1
Nutriprem 1	1.2:1
Nutriprem 2 (powder)	1.3:1
Gold Prem 1	1.1:1 (*would need 1.2mmol/kg of calcium for a ratio of 1.2:1)
Gold Prem 2 (powder)	1.2:1
Hydrolysed Nutriprem	1.3:1

Appendix 6: Parent Information Leaflet

The below information sheet has been designed to provide information to parents about MBDP and what they may expect in terms of investigations, management, handling and follow-up/discharge. However, it would need to be amended to be specific and accurate to local practices.

Metabolic bone disease of prematurity: information for families

What is metabolic bone disease of prematurity?
Metabolic bone disease of prematurity (MBDP) – sometimes called osteopenia of prematurity – is a condition where the baby's bones are *undermineralised;* there are less minerals in the bones. MBDP mainly affects babies that are born very preterm or very small. It is estimated to affect up to 23% of babies born weighing less than 1500g, and up to 60% of babies born weighing 1000g. It is a condition that is regularly diagnosed and treated in neonatal units.

During pregnancy, most of the minerals needed for healthy bones are laid down during the third trimester. When a baby is born prematurely, or if there is a problem with the placenta making the baby smaller than expected, this can mean that the baby has not had the opportunity to store enough protein and minerals, putting them at risk of MBDP.

MBDP can range from mild to severe. In mild cases there may only be changes to certain mineral and hormone levels in a baby's blood tests. In more severe cases, changes can occur in the baby bones, and there may be breaks or fractures that can be seen on an X-ray.

How is MBDP diagnosed?
There are blood tests that can screen to identify babies with MBDP. These include looking at the bone mineral and hormone levels (bone profile) in the blood, which are usually tested weekly on the neonatal unit. There are other special tests that are done from the 2nd or 3rd week of life looking at a specific bone hormone (parathyroid hormone - PTH). The PTH level helps the team to understand the cause and treat MBDP.

Prevention, early identification and treatment of babies with MBDP is crucial for optimal bone health in preterm babies. Unfortunately MBDP can be diagnosed late on some occasions, for example, after a fracture is noticed on x-ray. Babies with MBDP can have thin or more translucent (see-through) looking bones on x-rays. This can tell us how brittle the bones are.

How is MBDP treated/managed?
Providing the right amount of nutrition at the right time is the best way to prevent or reduce the severity of MBDP. This includes:

- starting nutrition as soon as possible after your baby is born, including the use of intravenous/parenteral nutrition (PN) if your baby is unable to tolerate milk
- using as much of mother's own breast milk as possible
- using breast milk fortifier at an early stage
- preventing or treating vitamin D deficiency
- and stopping intravenous/PN as soon as your baby tolerates full milk feeds

If your baby is diagnosed with MBDP, the neonatal team will ensure your baby receives the best nutrition possible. The next step is for the team to review your baby's blood tests to determine the underlying cause.

MBDP can be caused by:

- A phosphorus deficiency.
- A calcium deficiency.
- A vitamin D deficiency.

When the underlying cause is determined your baby may be given extra calcium and/or phosphorus supplements and their blood tests will be repeated in two weeks before any changes are made to the treatment plan.

How do I handle and look after my baby with MBDP?

Handling can be a stressful event for any infant on a neonatal unit, so this needs to be considered when performing any interaction, procedure, or tasks, including routine cares. It's important to talk to your infant and follow their cues (signals from your infant that tell you how they feel and what they need) and ensure tasks are completed at the infant's pace.

When you are handling and moving your infant, doing any cares such as nappy changes, dressing, feeding and cuddles you need to support their body and limbs until they are stronger and more active:

- Use widespread "splayed" hands to provide support to the body, head and limbs
- Try not to use a finger pincer grip on legs and arms, as this can cause a stress point which could result in a fracture while the bones are still fragile
- Try not to lift legs up by the ankles, when changing nappies or dressing
- Try not to pull on arms and legs when dressing.
- When moving your infant from the cot, gently slide your hand down into the mattress and under them, one hand under their head and trunk area and the other under their lower back, buttocks and lower limbs.
- Make sure their fingers and toes aren't caught in blankets or clothes when lifting them.

What happens when we go home?

When your baby is well enough, they will be discharged from hospital, and you can take them home. It is natural to have worries or concerns about this next stage, regardless of whether your baby has MBDP or not.

It is important to have all the information you need to care for your baby at home. Before you leave hospital, it is a good idea to write down key information and make a list of names and contact details, so that you know the best way to get help or advice if you need it. If you are unsure about anything, do not feel afraid to ask questions. The team will tell you if your baby needs to continue any medicines or supplements for MBDP at home. The hospital will send a discharge letter to your GP and health visitor with information about your child's medical condition.

Your baby may need to have blood tests to monitor the MBDP and decide how long they will continue to need treatment for, if they will be needing medicines for this at home. These may take place in hospital or at home. It is important to attend appointments and work together with your child's healthcare team so your baby can continue to receive the best care and the team can support you.

Your baby's medical team will continue to care for your baby at follow up appointments, these are called outpatient appointments. Although your baby may need some specialised care, they still have the same needs as any other baby. Attendance at clinics for vaccinations, developmental care and routine healthcare is as important for a baby with MBDP as any other child.

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