**Supplementary Appendix 1**

Survey distributed to members of the Pediatric Endocrine Society (PES) and the Canadian Pediatric Endocrine Group (CPEG).

Online Survey

Assessing Knowledge Gaps in Pediatric Bone and Mineral Disorders

The purpose of this survey is to identify knowledge gaps regarding pediatric bone and mineral disorders. The information will be used to guide development of PES educational materials and resources to meet the needs of pediatric endocrinologists in everyday practice, including diagnostic approaches and management guidelines.

We thank you for your time in completing this survey.

*Some questions will be available based on Redcap branching logic only.*

*A respondent can choose not to answer questions that are not in bold (optional questions).*

**Section 1: Disease Conditions and Care Team**

1. **Do you take care of patients with bone and mineralization disorders?** 
   1. Yes *(go to question 3 via branching logic)*
   2. No *(go to question 2 via branching logic)*
2. What is the reason why you do not take care of patients with bone and mineralization disorders?
   1. lack of training in diagnosis or treatment *(go to question 28 via branching logic)*
   2. other physicians in my facility are assigned to see them *(go to question 28 via branching logic)*
   3. unrecognized need in my institution *(go to question 28 via branching logic)*
   4. other (free text) *(go to question 28 via branching logic)*
3. **How comfortable are you with each condition? (0: not comfortable, 1: somewhat comfortable, 2: very comfortable)**
   * + 1. Primary osteoporosis
          1. Osteogenesis imperfecta
          2. Juvenile osteoporosis/idiopathic juvenile osteoporosis
          3. Other (specify)
       2. Secondary osteoporosis
          1. Associated with chronic disease (rheumatic disorders, inflammatory bowel diseases, Duchenne muscular dystrophy)
          2. Glucocorticoid-induced osteoporosis
          3. Leukemia
          4. Disuse osteoporosis (cerebral palsy)
          5. Eating Disorders
       3. Osteopetrosis
       4. Mineralization disorders
          1. Vitamin D deficiency rickets
          2. Disorders of vitamin D metabolism
          3. X-linked hypophosphatemic rickets
          4. Tumor-induced osteomalacia (TIO)
          5. Hypophosphatasia
       5. Focal bone disease
          1. Fibrous Dysplasia
          2. Chronic recurrent multifocal osteomyelitis (CRMO)
          3. Osteonecrosis
       6. Calcium Disorders
          1. Hyperparathyroidism
          2. Hypoparathyroidism
          3. Pseudohypoparathyroidism
          4. Other (free text)
       7. Recurrent fractures of unclear etiology
4. **At your institution, who treats patients with these disorders?** Select all that apply
   * + 1. Other endocrinologists
       2. Orthopedic surgery
       3. Genetics
       4. Nephrology
       5. Rheumatology
       6. General pediatrics
       7. Palliative Care/pain
       8. Others (free text)
       9. Don’t Know
5. **Do you have a bone clinic at your institution?**
   * + 1. Yes (*Go to question 7 via branching logic*)
       2. No (*Go to question 6 via branching logic*)
       3. Yes, but I do not participate in the bone clinic (*Go to question 6 via branching logic*)
6. Which health care professionals/services participate in the bone clinic? Select all that apply
   * + 1. Endocrinology
       2. Orthopedic surgery
       3. Nephrology
       4. General Pediatrics
       5. Geneticist
       6. Genetic counselor
       7. Palliative Care/Pain Management
       8. Audiology
       9. Dental
       10. Registered Dietician
       11. Physical Therapy
       12. Occupational Therapy
       13. Pool/aquatic Therapy
       14. Social worker
       15. Specialized nurse
       16. Care coordinator
       17. No other health care professional participates in my clinic
       18. Other (free text)
       19. Don’t Know
7. **At what age do patients with bone disorders at your institution transfer to adult care**?
   * + 1. After 18 years old
       2. After 21 years old
       3. After 25 years old
       4. After 30 years old
       5. Other (free text option)

**Section 2: Specific conditions and treatment approaches**

1. **When you are uncertain about the diagnosis or optimal management of patients with skeletal disorders, what do you typically do?** Select all that apply
   * + 1. Refer to the medical literature
       2. Contact experts in the field
       3. Refer to another center or colleague (specify which center)
       4. Other
2. In patients with primary osteoporosis (osteogenesis imperfecta or juvenile osteoporosis), what criteria do you use to start intravenous bisphosphonates?
   * + 1. Lumbar spine areal bone mineral density (aBMD) z-score by dual-energy x-ray absorptiometry (DXA) < - 2
       2. Lumbar spine aBMD z-score by DXA < -2 and low-energy fractures (including vertebral fractures)
       3. Low-energy fractures (including vertebral fractures) regardless of bone density
       4. Other (free text)
3. In patients with primary osteoporosis, what criteria do you use to discontinue bisphosphonates? Select all that apply
   * + 1. Continue for life
       2. Fused growth plates on x-ray
       3. Growth < 2 cm/year
       4. Lumbar spine aBMD z-score by DXA > -2
       5. Lumbar spine aBMD z-score by DXA > -1
       6. Lumbar spine aBMD z-score by DXA > 0
       7. Improvement in frequency of fractures
       8. Other (free text)
4. In patients with glucocorticoid-induced osteoporosis, what criteria do you use to start intravenous bisphosphonates?
   * + 1. Lumbar spine aBMD z-score by DXA< - 2
       2. Lumbar spine aBMD z-score by DXA < - 2 and low-energy fractures
       3. Low-energy fractures (including vertebral fractures) regardless of bone density
       4. Other (free text)
5. In patients with glucocorticoid-induced osteoporosis remaining on glucocorticoids (eg. Duchenne muscular dystrophy), what criteria do you use to discontinue bisphosphonates? Select all that apply
   * + 1. Continue for life
       2. Fused growth plates on x-ray
       3. Growth < 2 cm/year
       4. Lumbar spine aBMD z-score by DXA > -2
       5. Lumbar spine aBMD z-score by DXA > -1
       6. Lumbar spine aBMD z-score by DXA > 0
       7. Improvement in frequency of fractures
       8. Other (free text)
6. In patients with secondary osteoporosis in the context of a transient illness or in patients with glucocorticoid-induced osteoporosis who stop glucocorticoids, what criteria do you use to stop intravenous bisphosphonates?
   * + 1. Stabilization of osteoporosis phenotype after the transient illness is resolved or after glucocorticoids are discontinued (eg. reshaping of vertebral fractures or absence of non-vertebral fractures after patient achieved leukemia remission)
       2. Completion of growth
       3. I never treat patients with osteoporosis secondary to a transient process
       4. Immediately after glucocorticoids discontinuation or immediately after resolution of the transient illness
       5. Other (free text)
7. Since the approval of Burosumab (FGF-23 inhibitor) for X-linked hypophosphatemic rickets, what approximate percentage of your pediatric patients have successfully transitioned or started on Burosumab? (0%, 1-20%, 20-40%, 40-60%, 60-80%, 80-100%)
8. Do you have specific criteria for prescribing Burosumab to children with X-linked hypophosphatemic rickets?
   * + 1. No, I prescribe Burosumab to all my patients (*go to question 17 via branching logic*)
       2. Yes
9. Please specify what criteria you use for prescribing Burosumab in children with X-linked hypophosphatemic rickets (you can select more than one criterion).
   * + 1. Children with severe phenotype (severe bone deformities)
       2. Children with positive genetic testing
       3. Children who are non-adherent to activated vitamin D and oral PO4
       4. Children with significant side effects of activated vitamin D and phosphate
       5. All children in whom Burosumab is covered by insurance
       6. Other (free text)
10. For which clinical scenarios would you typically offer genetic testing (select all that apply)
    * + 1. Child with numerous low-trauma fractures but no extra-skeletal signs of osteogenesis imperfecta
        2. Osteogenesis imperfecta
        3. Infant or child with unexplained fractures and suspicion for inflicted injury
        4. I never offer genetic testing (free text)
11. When ordering genetic testing for a child with suspected bone fragility, what test to you typically order FIRST?
    * + 1. COL1A1 and COL1A2 sequencing
        2. Bone fragility sequencing panel, including COL1A1 and COL1A2 and other genes known to cause bone fragility
        3. Whole exome sequencing
        4. Other (free text)

**Section 3. Specific needs**

1. **How comfortable are you with the interpretation of DXA results (if done)? (0: not comfortable, 1: somewhat comfortable, 2: very comfortable, free text for comments)** (*if 0 or 1, go to question 20 using branching logic*) (*if 2, go to question 21 using branching logic*)
2. What are the reasons that you are not comfortable (or somewhat comfortable) with DXA interpretation? (free text)
3. **How comfortable are you with the use of bisphosphonate agents to treat osteoporosis in pediatric patients? (5: very comfortable, 1: not comfortable)**
4. How comfortable are you with the use of Burosumab? (0: not comfortable, 1: somewhat comfortable, 2: very comfortable, free text for comments) (*if 0 or 1, go to question 23 using branching logic*) (*if 2, go to question 24 using branching logic*)
5. What are the reasons that you are not comfortable (or somewhat comfortable) with Burosumab? (free text)
6. **What do you perceive are barriers faced by endocrinologists caring for patients with skeletal disorders?** Select all that apply
   1. Lack of available experts in my center
   2. Personal lack of knowledge/expertise in the area of skeletal disorders
   3. Paucity of clinical guidelines in the field
   4. Rarity of cases
   5. No infusion center for drug therapy
   6. Other (free text)
7. **Do you/Does your institution collaborate with other centers for research related to bone (both natural history studies and clinical trials)?**
   * + 1. Yes (*go to question 26 using branching logic)*
       2. No (*go to question 28 using branching logic)*
       3. Don’t Know (*go to question 28 using branching logic)*
8. Please describe with which center(s) and areas of bone research you collaborate (free text)
9. What types of studies you are working on (select all that apply).
   1. Interventional (Clinical Trial)
   2. Observational
   3. Patient Registry
   4. Other (free text)
10. **How can your PES Bone and Mineral Special Interest Group be helpful to you? (Can select more than one)**
    1. Provide a platform for consultation with bone experts
    2. Provide email lists of experts for each specific bone disease
    3. Provide databases and opportunities for research collaboration
    4. Provide online education for physicians on pediatric bone and mineral disorders, which includes updates on new therapy and management of rare bone diseases
    5. Other (free text)

**Section 4: Demographics and Training**

1. **Please name the hospital, city, state and country where you work. (Drop-down menu)**
2. **What is your job title?**
   1. Endocrine Fellow *(go to question 32 using branching logic)*
   2. Advanced Practice Provider *(end survey)*
   3. Attending *(go to question 31 using branching logic)*
3. In which year did you complete your endocrinology fellowship?
4. **Have you received sufficient clinical and/or didactic training in bone and mineral disorders during your medical training?**
5. Yes
6. No
7. Unsure (free text)

Thank you for your time completing this survey. We look forward to using this data to better serve the needs of our specialty.

**Supplementary Appendix 2**



**Supplementary Figure**. Survey branching logic. The number of respondents for each question and answer option is shown in brackets. The questions that did not employ branching logic are not shown.

**Supplementary Appendix 3.**

Proportions of respondents reporting being confident with various bone disorders in relation to their involvement in a bone clinic, years of experience, and location of practice

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | All Respon-dents | Bone clinic | No bone clinic | <10 years of practice | ≥10 years of practice | Practices in the US | Practices in Canada |
|  | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| Primary osteoporosis |  |  |  |  |  |  |  |
| Osteogenesis imperfecta (n=210) | 141(67) | 43 (67) | 95 (68) | 49 (65) | 54 (78) | 76 (73) | 16 (76) |
| Juvenile osteoporosis (n=210) | 142 (68) | 48 (75) | 92 (66) | 48 (63)b | 57 (83)b | 74 (71) | 18 (86) |
| Secondary osteoporosis |  |  |  |  |  |  |  |
| Associated with chronic disease (n=206) | 170 (83) | 56 (88) | 112 (81) | 63 (83) | 59 (87) | 86 (84) | 20 (95) |
| Glucocorticoid-induced (n=208) | 180 (87) | 57 (89) | 121 (86) | 64 (84) | 63 (90) | 90 (86) | 20 (95) |
| Leukemia (n=206) | 146 (71) | 51 (81)a | 93 (66)a | 53 (71) | 53 (77) | 75 (72) | 16 (76) |
| Disuse osteoporosis (n=207) | 150 (73) | 51 (81) | 97 (69) | 51 (67)b | 57 (83)b | 80 (76) | 16 (76) |
| Eating disorders (n=207) | 128 (62) | 48 (75)a | 78 (56)a | 40 (53)b | 51 (73)b | 68 (65) | 14 (67) |
| Mineralization disorders |  |  |  |  |  |  |  |
| Vitamin D deficiency rickets (n=205) | 203 (**99**) | 64 (100) | 138 (99) | 75 (99) | 69 (100) | 105 (100) | 20 (100) |
| Disorders of vitamin D metabolism (n=204) | 187 (**92**) | 61 (95) | 126 (91) | 66 (87)b | 68 (99)b | 95 (91) | 20 (95) |
| X-linked hypophosphatemia (n=203) | 174 (86) | 59 (92) | 115 (83) | 63 (84) | 65 (94) | 93 (90) | 17 (81) |
| Tumour induced osteomalacia (n=204) | 96 (47) | 37 (59)a | 59 (42)a | 27 (36)b | 44 (63)b | 58 (55)c | 6 (29)c |
| Hypophosphatasia (n=204) | 107 (53) | 43 (68)a | 64 (46)a | 32 (43)b | 47 (68)b | 58 (56)c | 6 (29)c |
| Focal bone diseases |  |  |  |  |  |  |  |
| Fibrous dysplasia (n=203) | 111 (55) | 38 (61) | 73 (52) | 32 (43)b | 48 (69)b | 57 (54) | 14 (67) |
| CRMO (n=202) | 37 (18) | 17 (27)a | 20 (14)a | 7 (9)b | 20 (29)b | 19 (18) | 5 (24) |
| Osteonecrosis (n=202) | 37 (18) | 18 (29)a | 19 (14)a | 8 (11)b | 19 (27)b | 17 (16)c | 9 (43)c |
| Calcium disorders |  |  |  |  |  |  |  |
| Hypoparathyroidism (n=203) | 201 (**99**) | 62 (100) | 139 (99) | 73 (99) | 70 (100) | 103 (100) | 20 (95) |
| Pseudohypoparathyroidism (n=204) | 192 (**94**) | 60 (94) | 132 (94) | 70 (92) | 67 (97) | 98 (94) | 20 (95) |
| Hyperparathyroidism (n=205) | 183 (89) | 61 (95) | 122 (87) | 65 (86) | 65 (93) | 95 (91) | 17 (81) |
| Others |  |  |  |  |  |  |  |
| Recurrent fractures of unclear etiology (n=205) | 146 (71) | 52 (81)a | 94 (67)a | 53 (70) | 54 (77) | 78 (74) | 15 (71) |
| Osteopetrosis (n=206) | 56 (27) | 28 (44)a | 28 (20)a | 15 (20) | 23 (33) | 27 (26) | 5 (24) |

Results are given as n (%) of participants reporting feeling confident (numerator: participants reporting feeling somewhat confident or very confident; denominator: number of respondents having answered each specific question, as shown at the beginning of each row). Physicians were deemed confident with a given condition when > 90% of all respondents reported being confident with a disease (proportions > 90% are highlighted in bold). Significant differences (p < 0.05) between the following proportions (using chi-square test) are shown as superscript: a participates in a bone clinic vs does not participate in a bone clinic; b <10 years vs ≥10 years experience; c practices in the US vs practices in Canada.

Abbreviations: CRMO, Chronic recurrent multifocal osteomyelitis; US, United States of America