Nutritional Deficiency – Impact on Toddler Development

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Aims of Discussion

• What do we know about toddler nutrition?
• Which Nutrients are at risk?
• What is the impact of nutritional deficiency on toddler development?
• What can be done?
UK Dietary Surveys

- National Diet and Nutrition Survey
- Age surveyed has changed
  - $1\frac{1}{2} - 4\frac{1}{2}$ (1995)
  - $1\frac{1}{2} - 3$ (2011)
UK Dietary Surveys

- Diet and Nutrition Survey of Infants and Young Children
  - 4-18 months (2011)
NDNS Rolling Survey

• Intakes of most vitamins met the RNI
  – Except Vit D – RNI 7 µg/day
• Mean intake 1.9 µg/day
  – 27% of RNI
  – 32% including supplements
Intakes of most vitamins met the RNI
- Except vitamin D

Mean intake 4 µg/day
- 57% of RNI

Higher intakes in younger

All breastfed below RNI
About Vitamin D

• Essential nutrient
• Needed for healthy bones
• Control blood calcium
• Associations with a range of diseases reported from observational studies
  – Cardiovascular disease
  – Cancers
About Vitamin D

- Only vitamin that cannot be met by diet alone
- Sunlight is the major source
- Supplements may be needed
- Two dietary forms
  - $D_2$ - Ergocholecalciferol
  - $D_3$ - Cholecalciferol
Vitamin D Deficiency

- Resurgence
  - Excessive sun protection
  - Lack of supplementation
  - Belief certain foods are high in vitamin D e.g. milk
  - Higher vitamin D requirements
  - Ethnic groups
    - 20-40% prevalence in UK Asian toddlers
At Risk Groups

- Pregnant and breastfeeding
  - Teenagers and young women
- Children under 5 years
  - 6 months to 3 years
- Adolescents
- Elderly
At Risk Groups

- Strict vegetarians and vegans
- Prolonged breastfeeding
  - Poor weaning
- Exclusion diets
- Malabsorption
- Disease states (liver, renal)
- Some drugs
At Risk Groups

- People with low sun exposure
  - Covering up for cultural reasons
  - Housebound

- People with darker skin
  - Cannot convert to active form so well
Vit D Status

• Assessment

• Insufficient
  • Plasma 25-OHD ≤ 50 nmol/l
    – Sub-optimal e.g. for bone health

• Deficient
  • Plasma 25 OHD ≤ 25 nmol/l
    – Associated with disease
Vit D status – UK toddlers

- DNSIYC 2011
  - Mean 25-OH-D
    - 5-11 months of age = 68.6 nmol/l
    - 12+ months of age = 64.3 nmol/l

• Only a small percentage of this sample were deficient
Deficiency and Risks

• Bone disease
  – Ricketts
  – Oesteomalacia
• Possible role in
  – Cancer
  – Heart disease
  – Diabetes
  – Multiple sclerosis
  – Arthritis
Deficiency - Symptoms

- Infants
  - Seizures
  - Cardiomyopathy
- Children
  - Poor growth
  - Rickets
Food Sources

- Oily fish (trout, salmon, mackerel, herring, sardine, tuna) 5-10 µg/100g
- Egg yolk 5 µg/100g
- Red meat 1µg/100g
- Breast milk 0.07µg/100ml
- Fortified Foods
  - Breakfast cereals 3-8 µg/100g
  - Margarine 7.5 µg/100g
  - Infant Formula ~1.2 µg/100ml
## Toddler Sources

- **DNSIYC in \( \mu g/day \)**
  - Infant formula \( 1.0 \)
  - Milk & Products \( 0.6 \)
  - Fat spreads \( 0.4 \)
  - Meat \( 0.5 \)
  - Commercial foods \( 0.3 \)
  - Fish \( \sim 0.05 \)
Deficiency Returns

- **West Midlands in 2001** - 24 children under 5 present with symptomatic vitamin D deficiency

- **Manchester** child health clinic – reports a rickets prevalence of 1.6%

- **Glasgow** - 160 cases including 3 white children

- **Southampton** - 8% of mostly white children attending a paediatric orthopaedic clinic had biochemical deficiency

- **Camden** – reports 5 cases of rickets last year
Vitamin D Sources

• Adequate exposure to sunlight
  – 20 – 30 minutes 2-3 times per week in summer
    – Dark skinned need greater exposure (2-10 times longer)

• Sunscreens
  • Avoid overuse but..
  • Avoid redness/burning
# Bridging the Gap

## Table 1

<table>
<thead>
<tr>
<th>UK Dietary Reference Values (DRV) for vitamin D</th>
<th>Recommended amount of vitamin D µg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Infants 1-7 months</td>
<td>8.5µg</td>
</tr>
<tr>
<td>Infants 7 months-3 years</td>
<td>7µg</td>
</tr>
<tr>
<td>4 years -64 years</td>
<td>No recommendation</td>
</tr>
<tr>
<td>Pregnant women or breastfeeding women</td>
<td>10µg</td>
</tr>
<tr>
<td>Men or women over the age of 65 years</td>
<td>10µg</td>
</tr>
</tbody>
</table>
## Preventing Deficiency

<table>
<thead>
<tr>
<th>Category</th>
<th>Dose IU</th>
<th>Dose ug</th>
<th>Examples of supplements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn up to 1 month</td>
<td>300 – 400 units daily</td>
<td>7.5 – 10 daily</td>
<td>Abidec, Dalivit, Baby D drops and Healthy Start</td>
</tr>
<tr>
<td>1 month – 18 years</td>
<td>400 – 1,000 units daily</td>
<td>10 – 25 daily</td>
<td>Abidec, Dalivit, Boots high strength vitamin D drops, Holland and Barrett Sunvite D3, Dlux oral spray, SunVitD3 and Vitabiotics tablets</td>
</tr>
</tbody>
</table>

Adapted from RCPCH Guide for Vitamin D in childhood
## Treating Deficiency

- Should only be done under medical supervision

<table>
<thead>
<tr>
<th>Category</th>
<th>Dose IU</th>
<th>Dose ug</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 6 months</td>
<td>1,000 to 3,000 units daily</td>
<td>25 – 75 daily</td>
<td>4 – 8 weeks</td>
</tr>
<tr>
<td>6 months – 12 years</td>
<td>6,000 units daily</td>
<td>150 daily</td>
<td>4 – 8 weeks</td>
</tr>
<tr>
<td>12 – 18 years</td>
<td>10,000 units daily</td>
<td>250 daily</td>
<td>4 – 8 weeks</td>
</tr>
</tbody>
</table>

Adapted from RCPCH Guide for Vitamin D in childhood
## Vitamin Supplements

<table>
<thead>
<tr>
<th></th>
<th>A (IU)</th>
<th>D (ug)</th>
<th>C (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy Start</td>
<td>700</td>
<td>7.5</td>
<td>20</td>
</tr>
<tr>
<td>Abidec</td>
<td>1333</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Dalivit</td>
<td>5000</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Haliborange</td>
<td>200</td>
<td>3.25</td>
<td>25</td>
</tr>
<tr>
<td>Well Kid</td>
<td>400</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Ddrops</td>
<td></td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
Healthy Start Vitamins

• Recommended for:
• All children up to age 5
• Pregnant & Breastfeeding mothers
• Infants
  – Breastfed where mothers may have low vitamin status
  – Formula fed receiving <500 ml/s formula daily

http://www.healthystart.nhs.uk/for-health-professionals/vitamins/
Uptake

- Survey of 13 PCTs in England
- < 10% of eligible families take up scheme
- Reasons
  - Poor accessibility
  - Low promotion by HCPs
  - Poor awareness
  - Motivation/beliefs

Jessiman et al, 2013
What can HCPs do

- Raise awareness
- Help set up an interest group
- Work with EYPs e.g. In Sure Start Centres
- Promote supplements, diet and outdoor play
- Refer families to already established groups
- Apply for funding e.g. Feeding For Life Best Practice Grant Scheme – Now Open

[http://www.feedingforlifefoundation.co.uk/home.aspx](http://www.feedingforlifefoundation.co.uk/home.aspx)
Provide Resources

Order from Nutrition and Diet Resources UK (NDR-UK). For more information visit [www.ndr-uk.org](http://www.ndr-uk.org) or call 0141 202 0690.
Provide Resources

- A practical approach to vitamin D supplementation in pregnant and breastfeeding women, infants and toddlers.
  - Available at: http://www.feedingforlifefoundation.co.uk
- Preventing vitamin D deficiency in toddlers
  - Available at: https://www.infantandtoddlerforum.org
“Low Vitamin D Levels Raise Anaemia Risk in children”

- Complex interplay between low levels of vitamin D and haemoglobin
- Regulation of immune inflammation
  - A catalyst for anaemia
- Not causal – associated with other factors

Atkinson et al., 2013
Iron and Development

• Brain development
  – Most rapid growth

• Iron needed for
  – Myelin formation
  – Biochemical syntheses
  – Neuronal growth/metabolism
Iron Requirements

• Highly conserved nutrient
  • No mechanism for excretion
  • Risk of overload
• Very reactive
• Useful to microbes
• Supplement with caution
Iron Requirements

• Healthy term infants use stores in first 6 months
• Dietary requirement is low
  • UK RNI
    • 0-3 months 1.7 mg/day
    • 4-6 months 4.3 mg/day
    • 7-12 months 7.8 mg/day
• Toddlers 1-3 years 6.9 mg/day
Iron Intake

- RNI 6.9 mg/day
- NDNS 2011 – age 1.5-4 years
  - Median intake 6.1 mg/day
    - 88% of RNI
- DNSIYC 2011 – age 12-18 mths
  - Mean intake 6.4 mg/day
    - 82% of RNI (7.8 mg/day)
Iron Deficiency

- Insufficient to maintain normal functions
  - Absorption is inadequate for needs
  - Long-term negative balance
  - Decrease in stores

- May be accompanied by symptoms (anaemia)
Iron Deficiency

• Main cause is poor intake
  – Dietary
    • Foods low in iron
    – Impaired absorption
    – Transport
  – Losses
  – Disease states
Iron Deficiency (ID)
- High prevalence globally
- Affects up to 50% children
- Can lead to iron deficiency anaemia (IDA)
  - Deficiency with disease symptoms
  - CMO ~26% UK children affected
Anaemia as a public health problem by country: Preschool-age children

Source:

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

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Category of public health significance (anaemia prevalence):
- Normal (<5.0%)
- Mild (5.0-19.9%)
- Moderate (20.0-39.9%)
- Severe (≥40.0%)
- No Data
Risk Factors

- Low birthweight
- Early cord clamping
- Males
- Social Factors
- Low meat intake
- High intake of cow’s milk
Assessing Iron Status

• Serum Iron:
  – Amount in blood – level may be normal even if the total amount of iron in the body is low

• Serum Ferritin:
  – Amount in stores

• Transferrin
  – Amount carried in blood
Identifying Deficiency

• **Haemoglobin - anaemia**
  - Less than 11.0 g/dL for both male and female children aged ≥ 10 months *(WHO, 2001)*

• **Ferritin - stores**
  - Serum Ferritin less than 12 µg/l for both male and female children aged ≥ 10 months *(SACN 2010, WHO, 2001)*
At Risk - Iron

- Iron deficiency in pregnancy linked to
  - IntraUterine Growth Retardation
  - Preterm birth
  - Low birthweight
At Risk - Iron

- Toddlers are at high risk due to rapid growth and high needs
- Prevalence
  - 12-30%
  - Depending on
    - Population
    - Screening method
Iron Status

- Anaemia in UK Preshoolers
- NDNS1995
  - 13%
- ALSPAC
  - 17%
- DNSIYC 2011
  - 2%
At Risk - Iron

- Ethnicity – high prevalence of anaemia in UK Asian families
  - Bradford 1986 – 25% of children aged 6-48 months admitted to hospital
  - Sheffield 1991 – 17%
  - England-wide – 20-30%

(Ehrhardt, 1986; Duggan, 1991; Lawson, 1998)
Possible Factors

- Restricted Diets
  - Vegetarian/Vegan
  - Cultural Exclusions

- Dietary Inhibitors of Iron
  - Phytates
  - Tannins
  - Cows milk

- Lack of Dietary Facilitators
Impact of Deficiency

• IDA associated with:
  – Lower development scores in toddlers
    Lozoff, Pediatrics, 1987
  – Reduced mental performance and behavioural problems
    Lozoff, Nutrition Reviews, 2006
    McCann, AJCN, 2007
Impact of Deficiency

• ALSPAC

• Longitudinal Study of Parents and Children

• Low Haemoglobin in infancy associated with poorer development in toddlers

Sherriff, 2001
Limitations of Studies

• Mainly Observational
  – Short Term Studies

• Lack
  – Randomised design
    • Confounded by other factors
  – Robust measures
  – Long Term Follow Up

• Unable to show causality
Aims of Discussion

• What do we know about toddler nutrition?
• Which Nutrients are at risk?
• What is the impact of nutritional deficiency on toddler development?
• What can be done?
Interventions

• Randomised Controlled Trials (RCT)

• Iron Supplementation:
  – No immediate benefits on psychomotor development
  – Evidence lacking for long-term effects
Systematic Reviews

- Meta-analyses
  - Conflicting
- Sachdev 2005
  - Small benefit for Mental Development Index with extra iron – 14 trials
- Szajewska 2010
  - Improvements in Psychomotor Development Index - 3 studies
- Wang 2013
  - No improvement for MDI or PDI
Systematic Reviews

• Effect of Iron Interventions on growth
  – 21 RCTs found no effect overall
  – Small effect in children ≥ 6 years of high dose supplement (>40mg/d)

• Developing countries
  – 26 RCTS benefits in deficient/anaemic only
  – Dose and duration important
  – Targeted approach may be useful

(Vesna Vucic et al., 2013, Iannotti et al., 2006)
Interventions – At Risk

- RCT of iron supplements in low birthweight infants
- Supplementation at 1-6 months compared with placebo
- Supplementation reduced behavioural problems at 3 years of age
- Main outcome:
  - Behaviour assessed using a checklist
  - Subjective measure

Berglund et al., 2013
Toddler Iron Sources

• DNSIYC in mg/day
  – Infant formula  1.1
  – Cereals        2.6
  – Infant cereals <0.1
  – Eggs          <0.1
<table>
<thead>
<tr>
<th>Food Source</th>
<th>mg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red meat (Beef highest)</td>
<td>1-3</td>
</tr>
<tr>
<td>Fish (Oily highest)</td>
<td>0.5-5</td>
</tr>
<tr>
<td>Eggs (Yolk highest)</td>
<td>2</td>
</tr>
<tr>
<td>Dried Fruits</td>
<td>2-6</td>
</tr>
<tr>
<td>Nuts</td>
<td>2-6</td>
</tr>
<tr>
<td>Pulses</td>
<td>2-3</td>
</tr>
<tr>
<td>Soya</td>
<td>2-4</td>
</tr>
<tr>
<td>Root vegetables</td>
<td>0.5-1</td>
</tr>
<tr>
<td>Green Leafy Veg</td>
<td>1.5-2</td>
</tr>
</tbody>
</table>
## Food Sources - Iron

<table>
<thead>
<tr>
<th>Food Source</th>
<th>mg/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fortified Foods</strong></td>
<td></td>
</tr>
<tr>
<td>Breakfast cereals</td>
<td>2-20</td>
</tr>
<tr>
<td>Bread</td>
<td>1-3.5</td>
</tr>
<tr>
<td>- Wholegrains highest</td>
<td></td>
</tr>
<tr>
<td><strong>Breast milk</strong></td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Infant Formula</strong></td>
<td>1.4</td>
</tr>
<tr>
<td><strong>Curry Powders</strong></td>
<td>30-60</td>
</tr>
</tbody>
</table>
Food Sources - Iron

• Haem iron
  – Found in foods of animal origin (Meat)
  – Most bioavailable

• Non-haem iron

• found in Plant foods and fortified cereals
  • If eaten with Vitamin C absorption improved
  • May be destroyed during cooking

• Inhibitors of Iron

• Tannins (tea), Phosphates, Phytate, Bran, Lignin, Cows’ milk
Summary - Iron

• IDA is a risk in toddlers
• Associated with cognitive and behavioural deficits
• Supplements may help at risk children
• Early screening may be helpful
• But
• Only a small number of trials
• Lacking:
  – Objective measures
  – Long term follow up
  – RCTs of iron interventions needed
Conclusions

• Toddlers are at risk of deficiencies in vitamin D and iron
• The risk is greater for certain groups of people - especially those with darker skin
• Supplementation can bridge the gap for vitamin D
• There is insufficient evidence to recommend universal supplementation with iron
• HCPs have an important role to play in providing appropriate advice