ILSI Regional Seminar on
Vitamin D in Nutrition and Health

Vitamin D Status and Intakes in Southeast Asia

Prof Khor Geok Lin
International Medical University, Malaysia

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Outline of Presentation

- Vitamin D status
- Vitamin D intake
- Issues
  - Multiple methods of determining serum vitamin D: the need for standardisation
  - various dietary assessment used: information gaps
  - dietary vitamin D2?
Vitamin D status
<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Sample Size</th>
<th>Age Range</th>
<th>Urban</th>
<th>Boys</th>
<th>Mean Serum (nmol/L)</th>
<th>Girls</th>
<th>Rural</th>
<th>Boys</th>
<th>Girls</th>
<th>&lt; 50 nmol/L (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INDONESIA (Sandjaja et al., 2013) N=1386</strong></td>
<td></td>
<td></td>
<td>5.0-12.0 years</td>
<td></td>
<td></td>
<td>52.9±1.6</td>
<td>50.3±1.8</td>
<td>54.3±2.1</td>
<td>48.2±2.2</td>
<td></td>
<td>35.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rural</td>
<td>Boys</td>
<td></td>
<td>54.3±2.1</td>
<td>48.2±2.2</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Girls</td>
<td></td>
<td>48.2±2.2</td>
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<tr>
<td><strong>MALAYSIA (Poh et al., 2013) N=1967 (n=616 for VD)</strong></td>
<td></td>
<td></td>
<td>7.0-12.0 years</td>
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<td></td>
<td>54.3±1.3***</td>
<td>43.2±1.4</td>
<td>56.6±1.9***</td>
<td>46.4±1.5</td>
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<td>48.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Urban</td>
<td>Boys</td>
<td></td>
<td>54.3±1.3***</td>
<td>43.2±1.4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Girls</td>
<td></td>
<td>43.2±1.4</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rural</td>
<td>Boys</td>
<td></td>
<td>56.6±1.9***</td>
<td>46.4±1.5</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Girls</td>
<td></td>
<td>46.4±1.5</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>THAILAND (Rojroongwasinkul et al., 2013) N=628</strong></td>
<td></td>
<td></td>
<td>6-12 years</td>
<td>Urban</td>
<td>Boys</td>
<td>51.9 (30.1, 73.0)</td>
<td>52.5 (43.2, 61.6)</td>
<td>18.3* (4.7, 50.4)</td>
<td>41.5 (21.6, 64.6)</td>
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<td></td>
<td></td>
<td></td>
<td>Rural</td>
<td>Boys</td>
<td></td>
<td>18.3* (4.7, 50.4)</td>
<td>41.5 (21.6, 64.6)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Girls</td>
<td></td>
<td>41.5 (21.6, 64.6)</td>
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<td></td>
</tr>
<tr>
<td><strong>VIETNAM (Nguyen et al., 2013) N=1920</strong></td>
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<td></td>
<td>6.0-11.9 years</td>
<td>Urban</td>
<td>Boys</td>
<td>56.5±3.1</td>
<td>51.1±2.9</td>
<td>55.6±2.9</td>
<td>57.0±2.9</td>
<td></td>
<td>46.7</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Rural</td>
<td>Boys</td>
<td></td>
<td>55.6±2.9</td>
<td>57.0±2.9</td>
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<td></td>
<td>Girls</td>
<td></td>
<td>57.0±2.9</td>
<td></td>
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</tr>
</tbody>
</table>

Sig difference between sexes * <0.05; ** <0.01; ***<0.001
Regional variation and determinants of vitamin D status in sunshine-abundant Thailand
La-or Chailurkit, W Aekplakorn and B Ongphiphadhanakul
BMC Public Health 2011, 11:853

Subjects consisted of 2,641 adults, aged 15 - 98 years, randomly selected from the Thai 4th National Health Examination Survey (2008-9) cohort.

Prevalence below 50nmol/L:
Bangkok 14.3%
Central 6.5%
North 4.3%
Northeast 2.8%
South 6.3%
### Vitamin D status and sun exposure in Southeast Asia
Hataikarn Nimitphong and Michael F. Holick
*Dermato-Endocrinology* 5:1, 34–37; 2013

<table>
<thead>
<tr>
<th>Study</th>
<th>Mean age years</th>
<th>Mean 25(OH)D (nmol/L)</th>
<th>% &lt; 50 nmol/L 25(OH)D</th>
<th>Predictors for vitamin D deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrition and Health of Aging Population in China Project n=3262</td>
<td>50-70</td>
<td>40.4</td>
<td>69</td>
<td>living in Beijing and urban area; higher education; family history of CVD and diabetes; being female</td>
</tr>
<tr>
<td>4th Korea National Health and Nutrition Examination Surveys n=6925</td>
<td>M: 42±20</td>
<td>M: 53±19</td>
<td>M: 2</td>
<td>living in urban areas; Indoor workers; no regular exercise; younger age (20–49 y)</td>
</tr>
<tr>
<td></td>
<td>F: 45±19</td>
<td>F: 46±18</td>
<td>F: 9</td>
<td>being female; younger age living in urban area and in Bangkok</td>
</tr>
<tr>
<td>Thai 4th National Health Examination Survey cohort n=2641</td>
<td>40±1</td>
<td>41±0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEA studies on vitamin D of Adults</td>
<td>Mean serum nmol/L</td>
<td>&lt; 50 nmol/L %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-------------------</td>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDONESIA (Sari et al., 2013) n=156</td>
<td>35.6±7.7 years</td>
<td>Female</td>
<td>47.0±17.5</td>
<td></td>
</tr>
<tr>
<td>MALAYSIA (Moy, 2011) N=380</td>
<td>48.5±5.2 years</td>
<td>Male</td>
<td>56.2±18.9</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>36.2±13.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>67.9</td>
<td></td>
</tr>
<tr>
<td>THAILAND (Nimitphong et al., 2013) n=1,990</td>
<td>25-54 years</td>
<td>Male</td>
<td>44±0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>47±0.5</td>
<td></td>
</tr>
<tr>
<td>THAILAND (Soontrapa et al., 2009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIETNAM (Lailou et al., 2013) N=595</td>
<td>years</td>
<td>Female</td>
<td>44.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>SINGAPORE (Robien et al., 2012) n=504</td>
<td>45-74 years</td>
<td>Male</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18</td>
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</tbody>
</table>
### SEA studies on vitamin D of Adults

<table>
<thead>
<tr>
<th></th>
<th>Mean serum nmol/L</th>
<th>&lt; 50 nmol/L %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JAKARTA AND KUAL LUMPUR (Green et al., (2008)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jakarta (n=126)</td>
<td>46 (43, 48)</td>
<td>63 (55, 72)</td>
</tr>
<tr>
<td>Kuala Lumpur (n=378)</td>
<td>49 (47, 50)</td>
<td>60 (55, 65)</td>
</tr>
<tr>
<td>Malay (n=133)</td>
<td>43 (40, 46)</td>
<td>74 (66, 81)</td>
</tr>
<tr>
<td>Chinese (n=123)</td>
<td>58 (55, 61)b</td>
<td>38 (30, 47)b</td>
</tr>
<tr>
<td>Indian (n=122)</td>
<td>45 (43, 48)</td>
<td>68 (60, 76)</td>
</tr>
</tbody>
</table>

bSignificantly different from other two ethnic groups, P<0.01.

|                |                   |               |
| **SINGAPORE (Hawkins (2009)** |                   |               |
| Chinese Male (n=40) |                   | 15            |
| Female (n=40)     |                   | 35            |
| Malay Male (n=40) |                   | 37.5          |
| Female (n=40)     |                   | 57.5          |
| Indian Male (n=40)|                   | 45            |
| Female (n=40)     |                   | 70            |
Prevalence of Vitamin D insufficiency and low bone mineral density in elderly Thai nursing home residents
Kruavit A et al., BMC Geriatrics 2012, 12:49

93 elderly Thai women who were living in institutional long-term nursing homes.

- Mean age of subjects was 75.2 ± 6.0 (SD) years.
- Mean 25(OH)D level was 64.3 ± 14.9 nmol/L
- Prevalence of vitamin D insufficiency: 25(OH)D level < 70 nmol/l was 38.7% (28.8%, 49.4%).

![Histogram of 25(OH)D levels](image.png)

*Figure 1: Frequency distribution of serum 25(OH)D concentrations of the subjects.*
Serum 25 Hydroxy Vitamin D [25(OH) D] Levels Among Admitted Filipino Elderly Patients
Mary Jane Tanchee-Ngo and Leilani B. Mercado-Asis
Philippine Journal of Internal Medicine 51:1-4, 2013

Elderly patients (n=25) with vitamin D deficiency and insufficiency at the UST Hospital, 2011-2012
Dietary intake of vitamin D
Dietary intake of vitamin D among Vietnamese children

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean Dietary Intake µg/day</th>
<th>Meeting RNI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6 months</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>6-12 months</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>12-24 months</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>24-36 months</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>36-60 months</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>0.13</td>
<td></td>
</tr>
</tbody>
</table>

The dietitians interviewed the women in charge of cooking and feeding the child meals. For consumption pattern, to calculate dietary micronutrients intakes, the database of consumed food items was linked to food composition data based on the Vietnamese food composition database.
Dietary intake of vitamin D among Malaysian children

<table>
<thead>
<tr>
<th>SEANUTS Study</th>
<th>Mean dietary intake µg/day</th>
<th>Meeting Malaysian RNI (2005) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brit J Nutr 2013, 110: S11-S20 (Indonesia); S21–S35 (Malaysia); S36–S44 (Thailand); S45–S56 (Vietnam)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MALAYSIA (Poh et al., 2013) N=3,502</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5-0.9 years Urban</td>
<td>5.9±0.5</td>
<td>37.1</td>
</tr>
<tr>
<td>Rural</td>
<td>7.3±0.6</td>
<td>15.1</td>
</tr>
<tr>
<td>1.0-3.9 years Urban</td>
<td>6.3±0.2</td>
<td>37.2</td>
</tr>
<tr>
<td>Rural</td>
<td>6.7±0.3</td>
<td>31.0</td>
</tr>
<tr>
<td>4.0-6.9 years Urban</td>
<td>5.5±0.1</td>
<td>51.4</td>
</tr>
<tr>
<td>Rural</td>
<td>5.7±0.2</td>
<td>47.9</td>
</tr>
<tr>
<td>7.0-12.0 years Urban</td>
<td>5.3±0.1</td>
<td>52.3</td>
</tr>
<tr>
<td>Rural</td>
<td>4.6±0.1</td>
<td>63.2</td>
</tr>
</tbody>
</table>

Dietary intake was assessed using semi-quantitative FFQ, with parents or carers as the proxy for children. According to three different age groups, three different sets of FFQ were developed and validated for the children.

The other participating countries of the SEANUTS study did not include vitamin D in their dietary assessment.
% Malaysian urban children (1-3 years) meeting RNI
(n=131)

<table>
<thead>
<tr>
<th>Category</th>
<th>Energy</th>
<th>Protein</th>
<th>Vit A</th>
<th>Vit C</th>
<th>Vit D</th>
<th>Folate</th>
<th>Calcium</th>
<th>Iron</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>82.4</td>
<td>99.4</td>
<td>66.3</td>
<td>88.5</td>
<td>66.3</td>
<td>80.7</td>
<td>72.4</td>
<td>86.7</td>
<td>77.4</td>
</tr>
<tr>
<td>Middle</td>
<td>80.6</td>
<td>98.6</td>
<td>70.9</td>
<td>87.5</td>
<td>51.4</td>
<td>82</td>
<td>79.4</td>
<td>86.2</td>
<td>72.2</td>
</tr>
<tr>
<td>High</td>
<td>85.8</td>
<td>100</td>
<td>64.3</td>
<td>94.7</td>
<td>80.3</td>
<td>87.5</td>
<td>78.5</td>
<td>92.8</td>
<td>82.1</td>
</tr>
</tbody>
</table>

Income category
% Malaysian urban children (4-6 years) meeting RNI (n=252)

<table>
<thead>
<tr>
<th></th>
<th>Energy</th>
<th>Protein</th>
<th>Vit A</th>
<th>Vit C</th>
<th>Vit D</th>
<th>Folate</th>
<th>Calcium</th>
<th>Iron</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>36.5</td>
<td>96.5</td>
<td>41.2</td>
<td>45.3</td>
<td>25.9</td>
<td>65.9</td>
<td>24.8</td>
<td>83.6</td>
<td>44.7</td>
</tr>
<tr>
<td>Middle</td>
<td>53.9</td>
<td>100</td>
<td>52.8</td>
<td>75.2</td>
<td>37.1</td>
<td>77.5</td>
<td>27</td>
<td>93.3</td>
<td>71.9</td>
</tr>
<tr>
<td>High</td>
<td>76.9</td>
<td>100</td>
<td>61.6</td>
<td>74.4</td>
<td>53.9</td>
<td>83.3</td>
<td>57.7</td>
<td>98.7</td>
<td>87.2</td>
</tr>
</tbody>
</table>
% Malaysian urban children (7-10 years) meeting RNI (n=316)

<table>
<thead>
<tr>
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<th>Energy</th>
<th>Protein</th>
<th>Vit A</th>
<th>Vit C</th>
<th>Vit D</th>
<th>Folate</th>
<th>Calcium</th>
<th>Iron</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>23.2</td>
<td>93.9</td>
<td>43.9</td>
<td>50</td>
<td>33</td>
<td>45.1</td>
<td>4.9</td>
<td>75.6</td>
<td>51.2</td>
</tr>
<tr>
<td>Middle</td>
<td>16.7</td>
<td>100</td>
<td>52.6</td>
<td>54.4</td>
<td>41.2</td>
<td>53.6</td>
<td>8.8</td>
<td>84.2</td>
<td>65.8</td>
</tr>
<tr>
<td>High</td>
<td>36.7</td>
<td>100</td>
<td>54.2</td>
<td>60.8</td>
<td>40</td>
<td>56.6</td>
<td>15</td>
<td>85.8</td>
<td>66.7</td>
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## Dietary intake of vitamin D among adults

<table>
<thead>
<tr>
<th>Country</th>
<th>Study</th>
<th>Sample Size</th>
<th>Age</th>
<th>Men</th>
<th>Women</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SINGAPORE</td>
<td>Robien et al., (2013)</td>
<td>n= 504</td>
<td>45-74 years</td>
<td>2.8 ± 1.8</td>
<td>2.4 ± 1.7</td>
<td>Sources: Food, Supplements. Total 6.15.2. Main sources of vitamin D: milk, eggs, tuna &amp; salmon sandwich, supplements. Sun exposure for outdoor athletes (90 mins/day)</td>
</tr>
<tr>
<td>VIETNAM</td>
<td>Laillou et al., (2013)</td>
<td>n=583</td>
<td></td>
<td>0.09 (0.04, 0.16)</td>
<td>0.21 (0.15, 0.30)</td>
<td>Sources: Food, Supplements. Total 6.15.2. Main sources of vitamin D: milk, eggs, tuna &amp; salmon sandwich, supplements. Sun exposure for outdoor athletes (90 mins/day)</td>
</tr>
<tr>
<td>MALAYSIA</td>
<td>Leong, Loh &amp; Neng (2013)</td>
<td>n= 64</td>
<td>18-25 years</td>
<td></td>
<td></td>
<td>Sources: Food, Supplements. Total 6.15.2. Main sources of vitamin D: milk, eggs, tuna &amp; salmon sandwich, supplements. Sun exposure for outdoor athletes (90 mins/day)</td>
</tr>
</tbody>
</table>
Vitamin D intake and its food sources in Taiwanese

Table 1. Gender-age-specific mean vitamin D intake, Taiwan, 1993-2002.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age (yr)</th>
<th>Vitamin D from food (µg/day)</th>
<th>DRIs %†</th>
<th>Vitamin D from supplements (µg/day)</th>
<th>Total vitamin D intake (µg/day)</th>
<th>DRIs %†</th>
<th>Source‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>6-12</td>
<td>4.52</td>
<td>90.3</td>
<td>0.698</td>
<td>5.21</td>
<td>104.0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>6-9</td>
<td>4.53</td>
<td>90.5</td>
<td>0.764</td>
<td>5.30</td>
<td>106.0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>10-12</td>
<td>4.51</td>
<td>90.1</td>
<td>0.633</td>
<td>5.16</td>
<td>103.0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>13-15</td>
<td>4.80</td>
<td>95.9</td>
<td>0.697</td>
<td>5.49</td>
<td>110.0</td>
<td>1</td>
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<td></td>
<td>16-18</td>
<td>4.89</td>
<td>97.9</td>
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<td>19-44</td>
<td>4.70</td>
<td>94.0</td>
<td>0.420</td>
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<td>102.0</td>
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<tr>
<td></td>
<td>45-64</td>
<td>5.26</td>
<td>52.6‡</td>
<td>0.202</td>
<td>5.47</td>
<td>54.7§</td>
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<td>13-50</td>
<td>4.83</td>
<td>96.6‡</td>
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<td>51-64</td>
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<td>57.0‡</td>
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<td>53.6‡</td>
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<td>0.716</td>
<td>6.17</td>
<td>61.7§</td>
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<td>70-74</td>
<td>5.34</td>
<td>53.4‡</td>
<td>1.230</td>
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<td>75-79</td>
<td>5.95</td>
<td>59.5‡</td>
<td>0.635</td>
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<td></td>
<td>≥80</td>
<td>4.52</td>
<td>45.2‡</td>
<td>1.480</td>
<td>6.00</td>
<td>60.0</td>
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</table>
(Lee et al., 2008 continued)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Female</th>
<th>6-12</th>
<th>78.1</th>
<th>0.825</th>
<th>4.73</th>
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<td>10-12</td>
<td>4.32</td>
<td>86.3</td>
<td>0.564</td>
<td>4.88</td>
<td>97.6</td>
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<td>76.9</td>
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<td>4.61</td>
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<td>13-50</td>
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<tr>
<td>51-64</td>
<td>4.59</td>
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<td>0.683</td>
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<td>5.69</td>
<td>56.9</td>
<td>1.365</td>
<td>7.06</td>
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<td>65-69</td>
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<td>0.760</td>
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</tr>
<tr>
<td>70-74</td>
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<td>1.120</td>
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<tr>
<td>75-79</td>
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<td>≥80</td>
<td>6.00</td>
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<td>8.67</td>
<td>86.7</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

† Vitamin D DRIs (AI): 5 μg/day (≤ 50 years old), 10 μg/day (>50 years old)
‡ Source:
1. The Nutrition and Health Surveys in Taiwan, 1993-1996
2. The Elderly Nutrition and Health Surveys in Taiwan, 1999-2000
3. The School Children Nutrition and Health Surveys in Taiwan, 2001-2002
§ The grey shading indicates the number of the food and supplement vitamin D < 2/3 DRIs,
### Table 7. Average vitamin D intake and major sources of selected countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Specification</th>
<th>Vitamin D from food (µg/day)</th>
<th>Vitamin D from food and supplements (µg/day)</th>
<th>Major sources (Top three)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current study</td>
<td>Men</td>
<td>4.70</td>
<td>5.12</td>
<td>Fish (58%), meat (10%), supplement (8.2%)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>3.85</td>
<td>4.39</td>
<td>Fish (39%), dairy (14%), supplement (12%)</td>
</tr>
<tr>
<td>Australia</td>
<td>Men</td>
<td>2.6-3.0</td>
<td></td>
<td>Fish (42%), fish (27%), margarine (27%)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>2.0-2.2</td>
<td></td>
<td>Fish (91%), eggs (3%), meat (2%)</td>
</tr>
<tr>
<td>Japan</td>
<td>Women</td>
<td>7.1</td>
<td>7.1</td>
<td>Fish (91%), eggs (3%), meat (2%)</td>
</tr>
<tr>
<td>Norway</td>
<td>Man</td>
<td>6.8</td>
<td></td>
<td>Supplement (42%), fish (27%), margarine (27%)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>5.9</td>
<td></td>
<td>Supplement (49%), fish (26%), margarine (23%)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Man</td>
<td>4.2</td>
<td></td>
<td>Meat (21%), fish (18%), margarine &amp; cereal (17%)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>3.7</td>
<td></td>
<td>Supplement (24%), fish (19%), cereal (16%)</td>
</tr>
<tr>
<td>United States</td>
<td>Man</td>
<td>8.12</td>
<td></td>
<td>Milk (58%), supplement (30%), cereal (5%)</td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>7.33</td>
<td></td>
<td>Supplement (40%), milk (39%), cereal (3%)</td>
</tr>
</tbody>
</table>
### Published natural vitamin D-3 content

<table>
<thead>
<tr>
<th></th>
<th>D3 µg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuna liver</td>
<td>32,500</td>
</tr>
<tr>
<td>Mackerel liver</td>
<td>2,400</td>
</tr>
<tr>
<td>Tilapia</td>
<td>4,530</td>
</tr>
<tr>
<td>Salmon</td>
<td>325 - 2490</td>
</tr>
<tr>
<td>Cod</td>
<td>18 - 69</td>
</tr>
<tr>
<td>Tuna meat</td>
<td>37 - 102</td>
</tr>
<tr>
<td>Mackerel meat</td>
<td>6 - 155</td>
</tr>
</tbody>
</table>

(Natural Vitamin D Content in Animal Products
## Published natural vitamin D-3 content

<table>
<thead>
<tr>
<th>Food</th>
<th>D3 µg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef liver</td>
<td>&lt; 0.5 – 140.8</td>
</tr>
<tr>
<td>Beef kidney</td>
<td>1.3 – 27.1</td>
</tr>
<tr>
<td>Beef muscle meat</td>
<td>0.5 – 9.5</td>
</tr>
<tr>
<td>Pork liver</td>
<td>4.0 – 12.5</td>
</tr>
<tr>
<td>Pork muscle meat</td>
<td>0.5 – 13.9</td>
</tr>
<tr>
<td>Chicken meat</td>
<td>2.0 – 3.0</td>
</tr>
<tr>
<td>Butter</td>
<td>2 - 10</td>
</tr>
<tr>
<td>Egg yolk</td>
<td>34 - 56</td>
</tr>
<tr>
<td>Egg whole</td>
<td>8 - 30</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Target group</th>
<th>Average oil consumption (g/day)</th>
<th>Vitamin D supplied through vegetable oil fortification (µg/day)</th>
<th>% of IOM EAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Level 7.5 µg/100 g</td>
<td>Level 10 µg/100 g</td>
</tr>
<tr>
<td>National fortification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>20.5</td>
<td>1.23</td>
<td>1.64</td>
</tr>
<tr>
<td>Children &lt; 5 yr</td>
<td>17.3</td>
<td>1.04</td>
<td>1.38</td>
</tr>
<tr>
<td>Rich adults</td>
<td>26.0</td>
<td>1.56</td>
<td>2.08</td>
</tr>
<tr>
<td>Poor adults</td>
<td>23.0</td>
<td>1.38</td>
<td>1.84</td>
</tr>
<tr>
<td>Vietnam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women of reproductive age</td>
<td>11.1</td>
<td>0.67</td>
<td>0.89</td>
</tr>
<tr>
<td>Children 6–59.9 mo</td>
<td>6.0</td>
<td>0.36</td>
<td>0.48</td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Adults</td>
<td>25.0</td>
<td>1.50</td>
<td>2.00</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>25.1</td>
<td>1.51</td>
<td>2.01</td>
</tr>
<tr>
<td>Lao People’s Democratic Republic Adults</td>
<td>4.9</td>
<td>0.29</td>
<td>0.39</td>
</tr>
<tr>
<td>Cambodia</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Adults</td>
<td>6.6</td>
<td>0.40</td>
<td>0.53</td>
</tr>
<tr>
<td>Philippines</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td>13.2</td>
<td>0.79</td>
<td>1.06</td>
</tr>
<tr>
<td>Malaysia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td>16.1</td>
<td>0.97</td>
<td>1.29</td>
</tr>
</tbody>
</table>
Issues

• Multi-methods for determining blood vitamin D

<table>
<thead>
<tr>
<th></th>
<th>Method</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>LC-MS/MS Liquid chromatography-tandem mass spectometry</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>HPLC High-performance liquid chromatography</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>IDS-radioimmunoassay IDS 25-hydroxyvitamin D RIA (Immunodiagnostic Systems, Boldon, UK)</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>IDS-enzyme immunoassay The IDS OCTEIA 25-hydroxyvitamin D (Immunodiagnostic Systems)</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Nichols Advantage Chemiluminescence assay (no longer available)</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Liaison 1 chemiluminescence immunoassay (CLIA) (DiaSorin Inc,US)</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Liaison 2 modified version TOTAL assay (CLIA) (DiaSorin Inc,US)</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Elecsys Electrochemiluminescence immunoassay (Roche Diagnostics, Penzberg, Germany)</td>
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</tbody>
</table>
Figure 1 Plots of the percentage difference in 25(OH)D3 concentrations measured in seven evaluated methods and by liquid chromatography-tandem mass spectrometry (LC-MS/MS) (% differences are plotted against the LC-MS/MS value). A total of 291 complete cases covering a representative concentration range between 6.5 and 240 nmol/L by means of LC-MS/MS are plotted.
<table>
<thead>
<tr>
<th>Malaysia</th>
<th>Thailand</th>
<th>Vietnam</th>
<th>Indonesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemiluminescence (CLIA) LIAISON (DiaSorin) (Poh et al., 2013)</td>
<td>CLIA LIAISON, DiaSorin</td>
<td>HPLC</td>
<td>Not specified</td>
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<tr>
<td>IDS OCTEIA 25(OH)D EIA kit (Immunodiagnostic, US) Ari et al., 2012</td>
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<tr>
<td>Chemiluminescence (CLIA) LIAISON (DiaSorin Inc, USA) (Khor et al., 2011)</td>
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<tr>
<td>Chemiluminescent immunoassay (CLIA) LIAISON (Moy, 2011)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemiluminescent immunoassay (CLIA) LIAISON (Moy &amp; Bulgiba, 2011)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radioimmunoassay (RIA) (DiaSorin, USA) (Green et al., 2008)</td>
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<td></td>
<td></td>
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<tr>
<td>Radioimmunoassay (RIA) (IDS, US) (Rahman et al., 2004)</td>
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</table>
The NIH Office of Dietary Supplements (ODS) and CDC National Center for Environmental Health (NCEH) established a vitamin D standardization program with a Standardization Coordinating Center at CDC.

“As a consequence of these widespread, method-related differences in results of total 25(OH)D, which have confounded international efforts to develop evidenced-based guidelines, the Vitamin D Standardization Program (VDSP) was established in November 2010.”

The goal of the VDSP is to promote a measurement of 25(OH)D that is accurate and comparable over time, location, and laboratory procedure to improve clinical and public health practice worldwide.”
<table>
<thead>
<tr>
<th>Country</th>
<th>Survey</th>
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<tbody>
<tr>
<td>Australia</td>
<td>Australian Health Survey (AHS)</td>
</tr>
<tr>
<td>Canada</td>
<td>Canadian Health Measures Survey (CHMS)</td>
</tr>
<tr>
<td>Germany</td>
<td>German Nutrition Survey (GeNuS) 1998</td>
</tr>
<tr>
<td></td>
<td>German Health Interview and Examination Survey for Children and Adolescents (KIGGS)</td>
</tr>
<tr>
<td></td>
<td>German Health Examination Survey for Adults 2008-2011 (DEGS)</td>
</tr>
<tr>
<td>Ireland</td>
<td>National Adult Nutrition Survey (NANS)</td>
</tr>
<tr>
<td>Mexico</td>
<td>The Mexican Health and Nutrition Survey 2006</td>
</tr>
<tr>
<td>South Korea</td>
<td>The Korean National Health and Nutrition Examination Survey (KNHANES)</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>National Diet and Nutrition Survey (NDNS)</td>
</tr>
<tr>
<td>USA</td>
<td>National Health and Nutrition Examination Survey (NHANES)</td>
</tr>
</tbody>
</table>
Issues

• Multiple dietary assessment methods
  – Vitamin D contents in unfortified and fortified foods - locally produced and imported: information gaps
  – Assessing intake of dietary supplements
Challenge in multi-country studies eg SEANUTS study

- **Thailand**: Food recall data were converted into nutrient intakes using the INMUCAL-N V. 2.0 computer software (Institute of Nutrition, Mahidol University).

- **Malaysia**: Nutrient values for each food item were obtained from the Nutrient Composition of Malaysian Foods, Composition of Foods Commonly Eaten in Singapore and food product labels.

- **Indonesia**: Analysis of dietary intake was done using the Nutrisoft program developed by the Food and Nutrition Research Center, using Indonesian food composition tables.

- **Vietnam**: Nutrient composition of the diet was estimated using the Nutrisoft program developed by the National Institute of Nutrition, using the Vietnamese food composition table. The nutrient intake values were then compared with the Vietnamese and FAO/WHO RDA.
“Accurate food composition data underpin the analysis of dietary intake surveys by converting food consumption data to nutrient intake data.

Such data remain central in elucidating the role of food components in health and disease”
Vitamin D2 versus D3 from diets and supplements
Comparison of vitamin D2 and vitamin D3 supplementation in raising serum 25-hydroxyvitamin D status: a systematic review and meta-analysis

“This meta-analysis indicates that vitamin D3 is more efficacious at raising serum 25(OH)D concentrations than is vitamin D2, and thus vitamin D3 could potentially become the preferred choice for supplementation”.
It is not known whether genetic variation in the vitamin D binding protein (DBP) influences 25-hydroxyvitamin D levels [25(OH)D] after vitamin D supplementation.

A total of 39 healthy female subjects received 400 IU of either vitamin D3 or D2, plus a calcium supplement, every day for 3 months.

Total serum 25(OH)D, 25(OH)D3 and 25(OH)D2 were measured by LC-MS/MS. Individual genotyping of rs4588 in the DBP gene was performed using real-time PCR.

Vitamin D3 tended to increase total 25(OH)D levels more when compared with the same dosage of vitamin D2 (p = 0.08). The underlying basis for this finding appears to be a concurrent decrease in 25(OH)D3 after supplementation with vitamin D2.

With D3 supplementation, subjects with CA or AA alleles had significantly less increase in 25(OH)D3 and total 25(OH)D when compared with those with the CC allele.

However, no difference was found when the supplement was vitamin D2.

“In conclusion, the present data demonstrate that 25(OH)D2 concentrations are present in the sera of adults from this nationally representative sample.

Vitamin D2 may have an impact on nutritional adequacy at a population level and thus warrants further investigation”. 
“Clearly, there is a need for sustainable food-based strategies to bridge the gap between current and recommended intakes of vitamin D to minimize the prevalence of vitamin D deficiency, but the development of such strategies requires, in the first instance, the ability to accurately assess vitamin D intakes in the population”.

Concluding remarks
Matthias Wacker and Michael F. Holick, 2013

Pushing the Knowledge Frontier of Vitamin D
Vitamin D beyond bone health

• The Association of vitamin D status and fasting glucose according to body fat mass in young healthy Thais
  (Nimitphong et BMC Endocrine Disorders 2013, 13:60)

• High prevalence of vitamin D insufficiency and its association with obesity and metabolic syndrome among Malay adults in Kuala Lumpur, Malaysia
  (Moy & Bulgiba BMC Public Health 2011, 11:735)

• The effect of vitamin D status on pediatric asthma at a University Hospital, Thailand

• Association of vitamin D deficiency with incidence of type 2 diabetes in high-risk Asian subjects

• Effect of adiposity, season, diet and calcium or vitamin D supplementation on the vitamin D status of healthy urban African and Asian-Indian adults
THANK YOU