Iodine and other nutritional predictors of infant and preschooler’s development: Results from a cluster randomized trial in Ethiopia

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¹McGill University, Canada, ²University of South Carolina, USA, ³University of Bahir Dar, Ethiopia, ⁴Ethiopian Public Health Institute, Ethiopia
39% of children under 5 years in low- and middle-income countries do not reach their mental development potential

Grantham-McGregor et al., 2007
Introduction

Child mental development

Child nutrition
- Stunting
- Breastfeeding
- Micronutrients (Iodine, Iron, Zinc, Selenium)

Child health
- Malaria
- Helminthes

Child care
- Psychosocial stimulation

Household
- Socio-economic status
- Hygiene
- Food insecurity

Mother
- Education
- Nutritional status
- Physical health
- Depression
- Autonomy
- Social support

Community
- Health services
- Women status

Grantham-McGregor et al., 2007; Walker et al., 2007; Engle et al., 2007
Introduction

Common approaches to fight iodine deficiency:
- Supplementation
- Fortification

WHO, 1994; http://www.flickr.com/photos/micronutrient_initiative/4787877916/sizes/m/in/photostream
Introduction

Universal salt iodization is the most cost-effective strategy to achieve the elimination of iodine deficiency disorders

WHO, 1994; http://www.flickr.com/photos/micronutrient_initiative/4787877916/sizes/m/in/photostream
## Iodine and mental development of < 5 years old children

<table>
<thead>
<tr>
<th>Study design</th>
<th>Effect size $d$</th>
<th>IQ score difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT (2 studies, Iodized oil)</td>
<td>0.68</td>
<td>10.2</td>
</tr>
<tr>
<td>Non-RCT (8 studies, Iodized oil, iodine supplement)</td>
<td>0.46</td>
<td>6.9</td>
</tr>
<tr>
<td>Cohort-Mother iodine status (9 studies)</td>
<td>0.52</td>
<td>7.8</td>
</tr>
<tr>
<td>Cohort-Infant iodine status (4 studies)</td>
<td>0.54</td>
<td>8.1</td>
</tr>
</tbody>
</table>

Bougma et al., 2013

**Randomized cluster effectiveness trial with iodized salt**

**Hypothesis:** Mental development scores will be higher in children exposed to iodized salt through lactation and/or direct consumption in comparison with children not exposed to iodized salt.
Study site

Why Ethiopia?

- National survey in 2005:
  - 4.2% of households use iodized salt
  - 39.9% of goiter
- Universal salt iodization legislation in 2011
- National iodization plant
- Unique opportunity

Abuye et al., 2007
Design

Amhara region

- Selected 6 out of 10 zones
- Randomly selected 60 out of 74 woreda
- Randomly selected 1 kebele per woreda
- Randomly assign kebele to treatment arm:
  - 30 intervention
  - 30 control
Ethics

- McGill Institutional Review Board (Canada)
- National Research Ethics Review Committee (NRERC) of Ethiopia
- Support letters (Ethiopia):
  - Amhara regional bureau of health
  - Zonal bureau of health
  - Woreda bureau of health
- Registered as clinical trial under ClinicalTrials.gov Identifier: NCT013496
Participants

Baseline

October 2011 – April 2012
- Infants: 8 mo (6 – 10)
- n = 1880
- Exhaustive sampling

Endline

March – October 2013
- Preschoolers: 57 mo (54 – 60)
- n = 1635

Lost-to-follow up:
- Interv. (13%) vs Ctrl (15%) ns

Lost-to-follow up:
- Interv. (7%) vs Ctrl (9%) ns
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development

Infants:
Bayley version III:
- Cognitive
- Expressive language
- Receptive language
- Fine motor
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development

Preschoolers:
- School readiness
- WPPSI
  - Similarities
  - Matrix reasoning
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development
- Anthropometry

- Weight
- Length/Height
- MUAC
- Edema
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development
- Anthropometry
- Thyroid size

Palpation (WHO classification)
- No Goiter
- Goiter grade 1 (Palpable)
- Goiter grade 2 (Visible neck extended)
- Goiter grade 3 (Visible from distance)
## Timeline of activities

### Baseline

**October 2011 – April 2012**

- Mental development
- Anthropometry
- Thyroid size
- Health

### Activities

- Illness (2 wk recall)
- Immunization
- Supplementation (vitamin A, Iodine)
- Deworming
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet

- Breastfeeding (Infants):
  - Initiation time
  - Type
- Diet:
  - Initiation
  - Food frequency
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet
- Psychosocial stimulation

- Infants
- Home Observation for Measurement of the Environment (HOME) Inventory
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet
- Psychosocial stimulation
- Urine and blood

- Urinary iodine
- Thyroid hormones
- Iron
- Inflammation
## Timeline of activities

### Baseline

**October 2011 – April 2012**

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet
- Psychosocial stimulation
- Urine and blood
- Maternal depressive symptoms

### Infants’ mother

- Center for Epidemiologic Studies Depression (CES-D) scale
Timeline of activities

<table>
<thead>
<tr>
<th>Baseline</th>
</tr>
</thead>
</table>

October 2011 – April 2012

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet
- Psychosocial stimulation
- Urine and blood
- Maternal depressive symptoms
- Gestational history

- Miscarriage, stillbirth
- Illness, complications
- Type, place of delivery
- Contraception
Timeline of activities

Baseline

October 2011 – April 2012

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet
- Psychosocial stimulation
- Urine and blood
- Maternal depressive symptoms
- Gestational history
- Socioeconomic status

- Household size
- Education of the mother and the father
- Occupancy of the mother and the father
- Assets
- Water and sanitation
- Livestock
## Timeline of activities

### Baseline

**October 2011 – April 2012**

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet
- Psychosocial stimulation
- Urine and blood
- Maternal depressive symptoms
- Gestational history
- Socioeconomic status
- Household salt

**Iodine**
- Rapid test (qualitative)
- Titration (quantitative)
### Timeline of activities

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2011 – April 2012</td>
<td>May 2012 -</td>
</tr>
</tbody>
</table>

- Mental development
- Anthropometry
- Thyroid size
- Health
- Breastfeeding and diet
- Psychosocial stimulation
- Urine and blood
- Maternal depressive symptoms
- Gestational history
- Socioeconomic status
- Household salt
## Timeline of activities

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<tr>
<th>Baseline</th>
<th>Intervention</th>
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</thead>
<tbody>
<tr>
<td>October 2011 – April 2012</td>
<td>May 2012 -</td>
</tr>
<tr>
<td>- Mental development</td>
<td>- Support early iodized salt distribution</td>
</tr>
<tr>
<td>- Anthropometry</td>
<td>- Social marketing</td>
</tr>
<tr>
<td>- Thyroid size</td>
<td>- Monitoring (Salt sample collection and analysis)</td>
</tr>
<tr>
<td>- Health</td>
<td></td>
</tr>
<tr>
<td>- Breastfeeding and diet</td>
<td></td>
</tr>
<tr>
<td>- Psychosocial stimulation</td>
<td></td>
</tr>
<tr>
<td>- Urine and blood</td>
<td></td>
</tr>
<tr>
<td>- Maternal depressive symptoms</td>
<td></td>
</tr>
<tr>
<td>- Gestational history</td>
<td></td>
</tr>
<tr>
<td>- Socioeconomic status</td>
<td></td>
</tr>
<tr>
<td>- Household salt</td>
<td></td>
</tr>
</tbody>
</table>
### Timeline of activities

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Intervention</th>
<th>Endline</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2011 – April 2012</td>
<td>May 2012 -</td>
<td>March – October 2013</td>
</tr>
</tbody>
</table>

- **Mental development**
- **Anthropometry**
- **Thyroid size**
- **Health**
- **Breastfeeding and diet**
- **Psychosocial stimulation**
- **Urine and blood**
- **Maternal depressive symptoms**
- **Gestational history**
- **Socioeconomic status**
- **Household salt**

- **Support early iodized salt distribution**
- **Social marketing**
- **Monitoring (Salt sample collection and analysis)**

- **Mental development**
- **Anthropometry**
- **Thyroid size**
- **Health**
- **Breastfeeding and diet**
- **Psychosocial stimulation**
- **Urine and blood**
- **Maternal depressive symptoms**
- **Gestational history**
- **Socioeconomic status**
- **Household salt**
Analysis

- Intention to treat analysis
- Covariates:
  - Age
  - Water and sanitation
  - Mother’s education
  - Family assets
  - Length/Height-for-age z score
  - Baseline mental development score
- Cluster adjusted ANCOVA (SAS proc mixed)
- Baron and Kenny mediation analysis

## Baseline characteristics of infants

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention(^a)</th>
<th>Control(^a)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>8.0±1.4</td>
<td>8.0±1.4</td>
<td>ns</td>
</tr>
<tr>
<td>Weight for age z score</td>
<td>-1.14±1.24</td>
<td>-1.25±1.22</td>
<td>0.08</td>
</tr>
<tr>
<td>Weight for length z score</td>
<td>-0.48±1.11</td>
<td>-0.52±1.10</td>
<td>ns</td>
</tr>
<tr>
<td>Length for age z score</td>
<td>-1.27±1.33</td>
<td>-1.39±1.30</td>
<td>0.06</td>
</tr>
<tr>
<td>Diet diversity (0-7)</td>
<td>0.9±0.9</td>
<td>0.8±0.9</td>
<td>ns</td>
</tr>
<tr>
<td>Water and sanitation (0-3)</td>
<td>1.2±0.8</td>
<td>1.4±0.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Assets (0-10)</td>
<td>4.7±0.9</td>
<td>4.7±0.9</td>
<td>ns</td>
</tr>
<tr>
<td>Child goiter (%)</td>
<td>0.6</td>
<td>0.7</td>
<td>ns</td>
</tr>
<tr>
<td>Maternal depression symptoms (0-60)</td>
<td>19.7±9.3</td>
<td>19.4±9.4</td>
<td>ns</td>
</tr>
<tr>
<td>Psychosocial stimulation (0-45)</td>
<td>19.9±4.7</td>
<td>20.6±4.5</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

\(^a\) Range: Intervention (n=842-880); Control (n=803-844)
Treatment effects on infants’ mental development

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention(^a)</th>
<th>Control(^a)</th>
<th>Effect size (d)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive(^b)</td>
<td>6.4 ± 2.4</td>
<td>6.1 ± 2.3</td>
<td>0.11</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Expressive language(^b)</td>
<td>6.4 ± 2.2</td>
<td>6.2 ± 2.1</td>
<td>0.08</td>
<td>ns</td>
</tr>
<tr>
<td>Receptive language(^b)</td>
<td>7.2 ± 2.6</td>
<td>6.9 ± 2.2</td>
<td>0.10</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Fine motor(^b)</td>
<td>8.0 ± 2.8</td>
<td>7.6 ± 2.7</td>
<td>0.12</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

\(^a\) Range: Intervention (n=730 – 733); Control (n=663 – 665); \(^b\) Standardized scores

Adjusted for clustering, age, HAZ, mother’s education, family assets, and baseline score
Iodized salt over the study time

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>21ppm</td>
<td>24ppm</td>
</tr>
<tr>
<td>67% ≥ 15 ppm</td>
<td>7.6</td>
<td>4.7</td>
</tr>
<tr>
<td>16% ≥ 15 ppm</td>
<td>93.8</td>
<td>89.3</td>
</tr>
<tr>
<td>13% ≥ 15 ppm</td>
<td>4.7</td>
<td>89.3</td>
</tr>
</tbody>
</table>
Variation of urinary iodine over the study time

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Median (µg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (Oct. 11-Apr.12)</td>
<td>32.2</td>
</tr>
<tr>
<td>Cohort mom (Jan.-Mar.13)</td>
<td>23.9</td>
</tr>
<tr>
<td>Endline (Mar.-Oct.13)</td>
<td>222.4</td>
</tr>
</tbody>
</table>

Urinary iodine concentration

- Intervention
- Control
Predictors of infants’ mental development

Model 1:
- Treatment

Model 2:
- Length/Height-for-age z score
  - Std $\alpha_1 = 0.051^*$
- Cognitive score
  - Std $\alpha_2 = 0.023^*$
- Treatment
  - Std $\beta' = 0.042$

Cognitive score
- Std $\beta = 0.055^*$
Baseline characteristics of preschoolers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention(^a)</th>
<th>Control(^a)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>57.0</td>
<td>57.0</td>
<td>ns</td>
</tr>
<tr>
<td>Weight-for-age z score</td>
<td>-1.47</td>
<td>-1.59</td>
<td>0.01</td>
</tr>
<tr>
<td>Weight-for-height z score</td>
<td>-0.74</td>
<td>-0.66</td>
<td>0.07</td>
</tr>
<tr>
<td>Height-for-age z score</td>
<td>-1.81</td>
<td>-1.70</td>
<td>ns</td>
</tr>
<tr>
<td>Diet diversity (0-7)</td>
<td>2.1</td>
<td>2.2</td>
<td>ns</td>
</tr>
<tr>
<td>Water and sanitation (0-3)</td>
<td>1.4</td>
<td>1.3</td>
<td>0.01</td>
</tr>
<tr>
<td>Assets (0-10)</td>
<td>4.7</td>
<td>4.8</td>
<td>ns</td>
</tr>
<tr>
<td>Child goiter (%)</td>
<td>22.7</td>
<td>23.2</td>
<td>ns</td>
</tr>
</tbody>
</table>
## Treatment effects on preschoolers’ mental development

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention(^a)</th>
<th>Control(^a)</th>
<th>Effect size (d)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School readiness</td>
<td>8.3 ± 4.8</td>
<td>7.9 ± 4.6</td>
<td>0.09</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>WPPSI matrix reasoning</td>
<td>6.0 ± 5.2</td>
<td>5.6 ± 5.0</td>
<td>0.08</td>
<td>ns</td>
</tr>
<tr>
<td>WPPSI similarities</td>
<td>10.5 ± 6.0</td>
<td>10.4 ± 5.6</td>
<td>0.02</td>
<td>ns</td>
</tr>
</tbody>
</table>
School readiness test means as a function of Iodized Salt and Dietary Diversity at baseline

Interaction of Diet diversity $\times$ Iodized salt, $t=2.85$, $p=0.09$
Conclusion

- Iodized salt has benefits for infants, mothers, and preschoolers:
  - Less goiter
  - Improved growth
  - Improved mental development

- Findings are consistent with literature on the effects of iodine supplementation on children mental development

- Effects could be higher than noted:
  - Low quality iodized salt
  - Contamination in the control group

- Salt iodization is important for Ethiopia but it has to be combined with other intervention (e.g., diet diversity, stimulation)
Funding and acknowledgement

- My supervisory committee
  - Dr Grace Marquis (McGill University)
  - Dr Frances Aboud (McGill University)
  - Dr Edward Frongillo (University of South Carolina)

- My colleagues:
  - Dr Dawd Gashu (Addis Ababa University)
  - Husein Mohammed (McGill University)
  - Tizita Lemma (Bahir Dar University)
  - Valerie Friesen (GAIN)
  - Daisy Singla (McGill University)

- The regional, zonal, woreda HB
- The health extension workers
- The research assistants
- The communities and study participants
Funding and acknowledgement
Funding and acknowledgement
Variation of urinary iodine over the study time

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline (Oct. 11-Apr.12)</td>
<td>75.7</td>
<td>48.2</td>
</tr>
<tr>
<td>Cohort mom (Jan.-Mar.13)</td>
<td>203.8</td>
<td>158.9</td>
</tr>
<tr>
<td>Endline (Mar.-Oct.13)</td>
<td>276.2</td>
<td>197.3</td>
</tr>
</tbody>
</table>
Variation of urinary iodine over the study time

![Graph showing urinary iodine excretion over time with intervention and control groups.](image-url)
Variation of urinary iodine over the study time

**Urinary iodine excretion**

- **Baseline (Oct. 11-Apr. 12)**
- **Cohort mom (Jan.-Mar. 13)**
- **Endline (Mar.-Oct. 13)**

- **Mean (µg/L)**
  - Intervention
  - Control
CONSORT flow diagram, Infants

- Assessed for eligibility (n=137 districts)
- Randomized (n=74 districts)
- Allocated to intervention (n=30 districts)
  - Infants (n=971)
  - Endline: 30 districts (n=842)
- Allocated to control (n=30 districts)
  - Infants (n=909)
  - Endline: 30 districts (n=768)
Assessed for eligibility (n=137 districts)

Randomized (n=74 districts)

Allocated to intervention (n=30 districts) Preschoolers (n=787)

Endline: 30 districts (n=727)

Allocated to control (n=30 districts) Preschoolers (n=838)

Endline: 30 districts (n=765)
Funding and acknowledgement
Treatment effects on infants’ mental development

Range: Intervention (n=730-733); Control (n=663-665); * p<0.05
### Predictors of infants' mental development

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Person’s correlation</th>
<th>Bayley subscales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cognitive</td>
</tr>
<tr>
<td>Length/Height-for-age z-score</td>
<td>0.205***</td>
<td>0.155***</td>
</tr>
<tr>
<td>Weight-for-age z-score</td>
<td>0.199***</td>
<td>0.132***</td>
</tr>
<tr>
<td>Deworming</td>
<td>0.059*</td>
<td>0.073*</td>
</tr>
<tr>
<td>Mother’s education</td>
<td>0.090**</td>
<td>0.119***</td>
</tr>
<tr>
<td>Maternal depression symptoms</td>
<td>-0.051</td>
<td>-0.067*</td>
</tr>
<tr>
<td>Psychosocial stimulation</td>
<td>0.294***</td>
<td>0.450***</td>
</tr>
<tr>
<td>Family assets</td>
<td>0.130***</td>
<td>0.126***</td>
</tr>
<tr>
<td>Water/Sanitation/Hygiene</td>
<td>0.112***</td>
<td>0.010***</td>
</tr>
</tbody>
</table>

*p<0.05; ** p<0.01; *** p<0.001
Predictors of infants' mental development

<table>
<thead>
<tr>
<th>Mental Outcome</th>
<th>Predictors</th>
<th>std β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive score</td>
<td>Model 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td>0.053</td>
<td>2.01</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Model 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td>0.035</td>
<td>1.26</td>
<td>ns</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td>0.114</td>
<td>4.06</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Length/Height for age z score</td>
<td></td>
<td>0.214</td>
<td>7.63</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Maternal depression</td>
<td></td>
<td>-0.04</td>
<td>-1.55</td>
<td>ns</td>
</tr>
<tr>
<td>Water/Sanitation/Hygiene</td>
<td></td>
<td>0.105</td>
<td>3.73</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
### Predictors of infants' mental development

<table>
<thead>
<tr>
<th>Mental Outcome</th>
<th>Predictors</th>
<th>std β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Receptive Language score</strong></td>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment</td>
<td>0.054</td>
<td>2.04</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Model 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment</td>
<td>0.038</td>
<td>1.32</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>0.029</td>
<td>1.02</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td>Length/Height for age z score</td>
<td>0.161</td>
<td>5.65</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Maternal depression</td>
<td>-0.062</td>
<td>-2.18</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Water/Sanitation/Hygiene</td>
<td>0.094</td>
<td>3.28</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Baseline characteristics of preschoolers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>Intervention</th>
<th>t or $X^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child age (mo)</td>
<td>57.0</td>
<td>57.0</td>
<td>0.13</td>
<td>.90</td>
</tr>
<tr>
<td>Sex (% girls)</td>
<td>49.0</td>
<td>49.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAZ</td>
<td>-1.6</td>
<td>-1.5</td>
<td>2.57</td>
<td>.01</td>
</tr>
<tr>
<td>HAZ</td>
<td>-1.8</td>
<td>-1.7</td>
<td>1.67</td>
<td>.11</td>
</tr>
<tr>
<td>Dietary diversity (0-7)</td>
<td>2.1</td>
<td>2.2</td>
<td>0.64</td>
<td>.53</td>
</tr>
<tr>
<td>Mother’s education (% any schooling)</td>
<td>5.2</td>
<td>5.1</td>
<td>0.07</td>
<td>.80</td>
</tr>
<tr>
<td>Father’s education (% any schooling)</td>
<td>10.2</td>
<td>10.1</td>
<td>0.07</td>
<td>.80</td>
</tr>
<tr>
<td>Family Assets (0-10)</td>
<td>4.7</td>
<td>4.8</td>
<td>0.92</td>
<td>.36</td>
</tr>
<tr>
<td>Water &amp; Sanitation(0-3)</td>
<td>1.4</td>
<td>1.3</td>
<td>3.22</td>
<td>.001</td>
</tr>
</tbody>
</table>
Treatment effects on preschoolers’ goiter

Baseline, Intervention group:
- No Goiter: 53%
- Goiter: 47%

Endline, Intervention group:
- No Goiter: 29%
- Goiter: 71%

Baseline, Control group:
- No Goiter: 55%
- Goiter: 45%

Endline, Control group:
- No Goiter: 24%
- Goiter: 76%

p<0.05
School readiness test means as a function of Iodized Salt and presence of Goiter at endline

Main effect of Iodized Salt, $F=2.85$, $p=.09$
Percentage of Children with Goiter

ANCOVA with clusters, F = 4.18, p = .04

<table>
<thead>
<tr>
<th></th>
<th>Baseline IS</th>
<th>Endline IS</th>
<th>Baseline Ctr</th>
<th>Endline Ctr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodized Salt</td>
<td>No Goiter</td>
<td>Grade 1</td>
<td>Grade 2</td>
<td>Grade 3</td>
</tr>
<tr>
<td>Sample</td>
<td>53</td>
<td>24.8</td>
<td>28.7</td>
<td>55.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20.5</td>
<td>30.6</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.6</td>
<td>1.3</td>
<td>21.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.2</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>24.5</td>
<td>33.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40.4</td>
</tr>
</tbody>
</table>

Baseline IS: Iodized Salt Sample
Endline IS: Iodized Salt Sample
Baseline Ctr: Control Sample
Endline Ctr: Control Sample

Percentage with goiter
Treatment effects on preschoolers’ mental development

School Readiness

<table>
<thead>
<tr>
<th></th>
<th>Controls</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Raw score (0-25)</td>
<td>5.22</td>
<td>5.39</td>
</tr>
<tr>
<td></td>
<td>7.98</td>
<td>8.41</td>
</tr>
</tbody>
</table>

p=.05
School readiness test means as a function of Iodized Salt and Dietary Diversity at baseline

Interaction of Diversity X Iodized Salt, $t=2.85$, $p=.09$