



# Effect of a Center-Based Early Childhood Care and Education Program on Child Nutritional Status: A Secondary Analysis of a Stepped-Wedge Cluster Randomized Controlled Trial in Rural Sindh, Pakistan

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**Effect of a center-based early childhood care and education program on child nutritional status: A stepped wedge cluster randomized controlled trial in rural Sindh, Pakistan**

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**Supplemental Table 1.** Balance of characteristics of clusters not censored and censored in the per-protocol analysis

	Clusters not censored	Clusters censored
Number of children (n)	998	91
Girls (n, %)	481(48.2%)	45(49.4%)
Age of children (mean, SD)	5.0 (0.4)	5.1 (0.4)
Enrolled in any schools (n, %)	656 (65.7%)	58 (63.7%)
Household Wealth Quintiles (mean, SD)	2.0 (1.4)	2.1 (1.4)
Food secure household (n, %)	481(48.2%)	49(53.9%)
Mid or moderate food insecurity household (n, %)	374(37.5%)	35(38.5%)
Severe food insecurity household (n, %)	143(14.3%)	7(7.7%)

**Supplemental Table 2.** LEAPS coverage in intervention clusters among children surveyed in each round (baseline excluded)

	Round 2	Round 3	End line	Overall
Children surveyed in LEAPS intervention clusters (n)	320	581	857	1,758
Attended LEAPS preschool (n, %)	248 (77.5%)	343 (59.0%)	613 (71.5%)	1204(68.2%)

**Supplemental Table 3.** Distribution of anthropometric measures among children 4.5-5.5 years by treatment and survey rounds

	Round 1	Round 2		Round 3		Round 4
	Baseline (n=1089)	Control (n=683)	Intervention (n=320)	Control (n=324)	Intervention (n=578)	Intervention (n=856)
Height-for-age z score, mean(SD)	-1.42(1.13)	-1.44(0.99)	-1.41(1.14)	-1.68(0.96)	-1.48(1.04)	-1.67(1.00)
BMI-for-age z score, mean(SD)	-0.69(0.97)	-0.96(0.88)	-0.93(0.87)	-0.62(0.90)	-0.93(0.86)	-0.64(0.90)
Weight-for-age z score, mean(SD)	-1.38(0.88)	-1.57(0.81)	-1.54(0.89)	-1.51(0.78)	-1.58(0.86)	-1.52(0.84)
Weight-for-height z score*, mean(SD)	-0.67(0.97)	-0.88(0.88)	-0.95(0.88)	-0.55(0.94)	-0.99(0.90)	-0.70(0.88)
MUAC-for age z score*, mean(SD)	-1.16(1.07)	-1.13(0.95)	-1.21(0.96)	-1.45(0.75)	-1.28(0.89)	-1.41(0.91)
Head circumference z scores *, mean(SD)	-0.96(0.78)	-1.24(0.67)	-1.37(0.64)	-1.25(0.62)	-1.41(0.72)	-1.32(0.66)
Stunted, n(%)	331 (30.59%)	198(28.99%)	106(33.12%)	121(37.35%)	187(32.35%)	318(36.92%)
Wasted, n(%)	85(7.86%)	76(11.13%)	42(13.12%)	24 (7.41%)	67(11.59%)	61(7.13%)
Underweight, n(%)	253(23.36%)	215(31.48%)	98(30.63%)	83(25.62%)	177(30.62%)	238(27.80%)

\*For WHZ, MUACZ and HCZ, we did subgroup analysis among children aged 4.5-5 years (n=2155)

**Supplemental Table 4.** Estimated per-protocol effect of LEAPS intervention on nutritional statuses of children aged 4.5-5.5 years(N=3570), rural Sindh, Pakistan \*\*

	LEAPS per-protocol effect	P value	ICC
<b>Continuous outcomes</b>	<b>Mean difference (95% Confidence Interval)</b>		
Height-for-age z score (HAZ)	0.11 (-0.01, 0.23)	0.06	0.06
BMI-for-age z score (BMIZ)	-0.12 (-0.23, -0.02)	0.02	0.06
Weight-for-age z score (WAZ)	-0.01 (-0.10, 0.08)	0.84	0.07
Weight-for-height z score* (WHZ)	-0.27 (-0.41, -0.14)	<0.001	0.06
MUAC-for age z score* (MUACZ)	-0.17 (-0.28, -0.07)	0.002	0.06
Head circumference z scores*(HCZ)	0.06 (-0.08, 0.21)	0.40	0.08
<b>Bivariate outcomes</b>	<b>Odds Ratio (95% Confidence interval)</b>		
Stunted (HAZ < -2)	1.00 (0.78, 1.28)	0.97	0.06
Wasted (WHZ < -2 / BMI Z < -2)	1.39 (0.96, 2.02)	0.08	0.10
Underweight (WAZ < -2)	1.09 (0.85, 1.41)	0.47	0.05

\*ICC= Intra cluster correlation coefficient

**Supplemental Table 5.** As treated\* analysis of the effect of LEAPS intervention on anthropometric indicators for children aged 4.5-5.5 years in rural Sindh, Pakistan (N= 3,268)

Outcome	LEAPS intervention effect	P value	ICC*
<b>Continuous outcomes</b>	<b>Mean Difference (95% Confidence Interval)</b>		
Height-for-age z score (HAZ)	0.13 (0.01, 0.25)	0.04	0.07
BMI-for-age z score (BMIZ)	-0.13 (-0.25, -0.03)	0.01	0.06
Weight-for-age z score (WAZ)	-0.01 (-0.10, 0.09)	0.87	0.07
Weight-for-height z score (WHZ)	-0.35 (-0.50, -0.20)	<0.001	0.06
MUAC-for age z score (MUACZ)	-0.16 (-0.27, -0.04)	<0.01	0.06
Head circumference z scores(HCZ)	0.07 (-0.08, 0.23)	0.35	0.07
<b>Binary outcomes</b>	<b>Odds Ratio (95% Confidence Interval)</b>		
Stunted (HAZ < -2)	1.01 (0.77, 1.31)	0.96	0.07
Wasted (WHZ < -2 / BMI Z < -2)	1.30 (0.88, 1.93)	0.19	0.09
Underweight (WAZ < -2)	1.11 (0.85, 1.46)	0.43	0.06

\*Association of intervention children who received the LEAPS intervention as compared to the control group.

\*\*ICC= Intra cluster correlation coefficient

Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level and the household wealth index.

**Supplemental Table 6.** Sensitivity analyses of the effect of LEAPS intervention on height-for-age z score with different model specifications

Models	LEAPS intervention effect on mean difference in Height-for-age z score (95% Confidence Interval)	P value
Linear mixed effects model with cluster fixed effect	0.14 (0.02, 0.26)	0.03
Linear mixed effects model including random effects interaction of cluster and time	0.13 (-0.00, 0.27)	0.06
Linear mixed effects model including random effects interaction of intervention and cluster	0.13 (-0.00, 0.27)	0.06
Generalized Estimating Equation (GEE) model	0.13 (0.00, 0.26)	0.05
Multivariable adjusted linear mixed effects model*	0.13 (0.02, 0.24)	0.02

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level and the household wealth index

**Supplemental Table 7.** Sensitivity analyses of the effect of LEAPS intervention on BMI-for-age z score with different model specifications

Models	LEAPS intervention effect on mean difference in BMI-for-age z score (95% Confidence Interval)	P value
Linear mixed effects model with cluster fixed effect	-0.13 (-0.24, -0.03)	0.01
Linear mixed effects model including random effects interaction of cluster and time	-0.13 (-0.23, -0.03)	0.01
Linear mixed effects model including random effects interaction of intervention and cluster	-0.13 (-0.24, -0.02)	0.02
Generalized Estimating Equation (GEE) model	-0.13 (-0.22, -0.04)	<0.01
Multivariable adjusted linear mixed effects model*	-0.13 (-0.23, -0.03)	<0.01

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level and the household wealth index

**Supplemental Table 8.** Sensitivity analyses of the effect of LEAPS intervention on Weight-for-age z score with different model specifications

Models	LEAPS intervention effect on mean difference in Weight-for-	P value
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	age z score (95% Confidence Interval)	
Linear mixed effects model with cluster fixed effect	-0.00 (-0.09, 0.09)	0.95
Linear mixed effects model including random effects interaction of cluster and time	-0.00 (-0.10, 0.10)	0.99
Linear mixed effects model including random effects interaction of intervention and cluster	-0.00 (-0.09, 0.10)	0.96
Generalized Estimating Equation (GEE) model	-0.00 (-0.09, 0.09)	0.96
Multivariable adjusted linear mixed effects model*	-0.00 (-0.09, 0.09)	0.98

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level, and the household wealth index

**Supplemental Table 9.** Sensitivity analyses of the effect of LEAPS intervention on Weight-for-height z score with different model specifications

Models	LEAPS intervention effect on mean difference in Weight-for-height z score (95% Confidence Interval)	P value
Linear mixed effects model with cluster fixed effect	-0.31 (-0.45, -0.16)	<0.001
Linear mixed effects model including random effects interaction of cluster and time	-0.28 (-0.42, -0.15)	<0.001
Linear mixed effects model including random effects interaction of intervention and cluster	-0.29 (-0.43, -0.15)	<0.001
Generalized Estimating Equation (GEE) model	-0.29 (-0.42, -0.15)	<0.001
Multivariable adjusted linear mixed effects model*	-0.31 (-0.44, -0.17)	<0.001

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level and the household wealth index

**Supplemental Table 10.** Sensitivity analyses of effect of LEAPS intervention on MUAC-for-age z score with different model specifications

Models	LEAPS intervention effect on mean difference in MUAC-for-age z score (95% Confidence Interval)	P value
Linear mixed effects model with cluster fixed effect	-0.17 (-0.28, -0.06)	<0.01
Linear mixed effects model including random effects interaction of cluster and time	-0.15 (-0.26, -0.04)	<0.01
Linear mixed effects model including random effects interaction of intervention and cluster	-0.16 (-0.27, -0.05)	<0.01
Generalized Estimating Equation (GEE) model	-0.16 (-0.25, -0.06)	<0.01
Multivariable adjusted linear mixed effects model*	-0.16 (-0.26, -0.06)	<0.01

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level and the household wealth index.



**Supplemental Table 11.** Sensitivity analyses of effect of LEAPS intervention on Head circumference-for-age z score with different model specifications

Models	LEAPS intervention effect on mean difference in Head circumference-for-age z score (95% Confidence Interval)	P value
Linear mixed effects model with cluster fixed effect	0.12 (-0.03, 0.27)	0.13
Linear mixed effects model including random effects interaction of cluster and time	0.08 (-0.06, 0.22)	0.24
Linear mixed effects model including random effects interaction of intervention and cluster	0.08 (-0.06, 0.22)	0.24
Generalized Estimating Equation (GEE) model	0.09 (-0.05, 0.21)	0.20
Multivariable adjusted linear mixed effects model*	0.10 (-0.04, 0.23)	0.18

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity index and the household wealth index.

**Supplemental Table 12.** Sensitivity analyses of the effect of LEAPS intervention on stunting (Height-for-age < -2)) with different model specifications

Models	LEAPS intervention effect: Odds Ratio (95% Confidence Interval)	P value
Binomial mixed effects model with cluster fixed effect	0.89 (0.68, 1.16)	0.40
Binomial mixed effects model including random effects interaction of cluster and time	0.92 (0.71, 1.22)	0.58
Binomial mixed effects model including random effects interaction of intervention and cluster	0.92 (0.69, 1.23)	0.57
Generalized Estimating Equation (GEE) model	0.93 (0.71, 1.21)	0.59
Multivariable adjusted binomial mixed effects model*	0.92 (0.72, 1.16)	0.30

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level and the household wealth index.

**Supplemental Table 13.** Sensitivity analyses of the effect of LEAPS intervention on wasting (Weight-for-height < -2/ BMI-for-age z score < - 2) with different model specifications

Models	LEAPS intervention effect on Odds Ratio (95% Confidence Interval)	P value
Binomial mixed effects model with cluster fixed effect	1.30 (0.86, 1.99)	0.22
Binomial mixed effects model including random effects interaction of cluster and time	1.33 (0.94, 1.91)	0.11
Binomial mixed effects model including random effects interaction of intervention and cluster	1.34 (0.93, 1.92)	0.11
Generalized Estimating Equation (GEE) model	1.31 (0.99, 1.74)	0.04
Multivariable adjusted binomial mixed effects model*	1.31 (0.91, 1.88)	0.14

\*Model adjusted for child age, sex, and birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level and the household wealth index.

**Supplemental Table 14.** Sensitivity analyses of the effect of LEAPS intervention on underweight (Weight-for-age z score < -2) with different model specifications

Models	LEAPS intervention effect Odds Ratio (95% Confidence Interval)	P value
Binomial mixed effects model with cluster fixed effect	1.04 (0.79, 1.38)	0.76
Binomial mixed effects model including random effects interaction of cluster and time	1.05 (0.81, 1.37)	0.67
Binomial mixed effects model including random effects interaction of intervention and cluster	1.05 (0.81, 1.36)	0.70
Generalized Estimating Equation (GEE) model	1.05 (0.84, 1.33)	0.63
Multivariable adjusted binomial mixed effects model*	1.05 (0.82, 1.34)	0.71

\*Model adjusted for child age, sex, birth order, number of children in the household, mother's education levels, father's education levels, family structure (nuclear/extended), household food insecurity level, and the household wealth index.

**Supplemental Table 15.** Stratified analysis of the effect of LEAPS intervention on child nutritional outcomes by sex of the children

	Male n=1937	Female n=1921	P-value for effect modification
<b>Continuous outcomes</b>	<b>Mean Difference (95% Confidence Interval)</b>		
Height-for-age z score (HAZ)	0.19(0.06, 0.32)	0.07(-0.06, 0.20)	0.09
BMI-for-age z score (BMIZ)	-0.12(-0.24, -0.01)	-0.14(-0.25, -0.03)	0.80
Weight-for-age z score (WAZ)	0.04(-0.06, 0.15)	-0.04(-0.15, 0.06)	0.08
Weight-for-height z score (WHZ)	-0.24(-0.40, -0.08)	-0.33(-0.49, -0.18)	0.23
MUAC-for age z score (MUACZ)	-0.09(-0.21, 0.03)	-0.22(-0.34, -0.10)	0.03
Head circumference z scores (HCZ)	0.17(0.01, 0.34)	-0.01(-0.17, 0.15)	0.02
<b>Binary outcomes</b>	<b>Odds Ratio (95% Confidence Interval)</b>		
Stunted (HAZ < -2)	0.80(0.60, 1.06)	1.06(0.81, 1.40)	0.05
Wasted (WHZ < -2 / BMI Z < -2)	1.21(0.79, 1.84)	1.49(0.97, 2.28)	0.36
Underweight (WAZ < -2)	0.93(0.70, 1.25)	1.20(0.90, 1.58)	0.10

**Supplemental Table 16.** Stratified analysis of the effect of LEAPS intervention on child nutritional outcomes by age groups

	Age <5 years n=2160	Age ≥5 years n=1692	P-value for effect modification
<b>Continuous outcomes</b>	<b>Mean Difference (95% Confidence Interval)</b>		
Height-for-age z score (HAZ)	0.21(0.08, 0.34)	0.05(-0.08, 0.18)	0.01
BMI-for-age z score (BMIZ)	-0.23(-0.34, -0.11)	-0.04(-0.15, 0.07)	<0.001
Weight-for-age z score (WAZ)	-0.01(-0.11, 0.10)	0.00(-0.10, 0.11)	0.89
Weight-for-height z score (WHZ)	-0.29(-0.42, -0.15)	-	
MUAC-for age z score (MUACZ)	0.08(-0.06, 0.22)	-	
Head circumference z scores (HCZ)	-0.17(-0.26, -0.05)	-	
<b>Binary outcomes</b>	<b>Odds Ratio (95% Confidence Interval)</b>		
Stunted (HAZ < -2)	0.75(0.57, 0.99)	1.18(0.89, 1.56)	<0.01
Wasted (WHZ < -2 / BMI Z < -2)	1.64(1.06, 2.54)	1.12(0.74, 1.70)	0.10
Underweight (WAZ < -2)	1.03(0.77, 1.37)	1.10(0.83, 1.46)	0.66

**Supplemental Table 17.** Stratified analysis of the effect of LEAPS intervention on child nutritional outcomes by household socioeconomic status (below or above the median)

	SES < median n=1937	SES > median n=1921	P-value for effect modification
<b>Continuous outcomes</b>	<b>Mean Difference (95% Confidence Interval)</b>		
Height-for-age z score (HAZ)	0.11(-0.02, 0.24)	0.15(0.02, 0.28)	0.55
BMI-for-age z score (BMIZ)	-0.11(-0.23, -0.00)	-0.14(-0.25, -0.03)	0.65
Weight-for-age z score (WAZ)	-0.00(-0.11, 0.10)	0.00(-0.10, 0.11)	0.92
Weight-for-height z score (WHZ)	-0.25(-0.41, -0.10)	-0.32(-0.47, -0.16)	0.40
MUAC-for age z score (MUACZ)	-0.17(-0.29, -0.05)	-0.14(-0.25, -0.02)	0.53
Head circumference z scores (HCZ)	0.12(-0.04, 0.28)	0.06(-0.11, 0.22)	0.45
<b>Binary outcomes</b>	<b>Odds Ratio (95% Confidence Interval)</b>		
Stunted (HAZ < -2)	0.90(0.68, 1.19)	0.96(0.73, 1.26)	0.69
Wasted (WHZ < -2 / BMI Z < -2)	1.04(0.69, 1.58)	1.77(1.13, 2.76)	0.03
Underweight (WAZ < -2)	0.96(0.72, 1.28)	1.17(0.88, 1.55)	0.19

**Supplemental Table 18.** Stratified analysis of the effect of LEAPS intervention on child nutritional outcomes by household food insecurity

	Food secure n=1449	Mild to moderate food insecure n=1929	Severe food insecure N=480	P-value for effect modification
<b>Continuous outcomes</b>	<b>Mean Difference (95% Confidence Interval)</b>			
Height-for-age z score (HAZ)	0.13(-0.02, 0.28)	0.12(-0.00, 0.25)	0.15(-0.06, 0.36)	0.97
BMI-for-age z score (BMIZ)	-0.19(-0.32, -0.07)	-0.11(-0.22, 0.00)	-0.07(-0.25, 0.11)	0.27
Weight-for-age z score (WAZ)	-0.05(-0.16, 0.07)	0.01 (-0.09, 0.11)	0.06(-0.10, 0.23)	0.41
Weight-for-height z score (WHZ)	-0.38(-0.55, -0.21)	-0.24(-0.40, -0.10)	-0.21(-0.45, 0.03)	0.22
MUAC-for age z score (MUACZ)	-0.21(-0.34, -0.08)	-0.16(-0.28, -0.04)	-0.00(-0.19, 0.18)	0.09
Head circumference z scores (HCZ)	-0.01(-0.18, 0.17)	0.07(-0.09, 0.22)	0.38(0.13, 0.63)	0.01
<b>Binary outcomes</b>	<b>Odds Ratio (95% Confidence Interval)</b>			
Stunted (HAZ < -2)	0.95(0.69, 1.29)	0.94(0.71, 1.23)	0.84(0.54, 1.31)	0.87
Wasted (WHZ < -2 / BMI Z < -2)	1.75(1.07, 2.85)	1.22(0.82, 1.83)	1.00(0.48, 2.08)	0.24
Underweight (WAZ < - 2)	1.27(0.92, 1.75)	0.98(0.74, 1.29)	0.98(0.62, 1.55)	0.26