

Supplemental Information

STUDY POPULATION

Bangladesh

Despite remarkable economic growth in recent years, Bangladesh ranks 146th out of 187 countries in terms of development.^{36,37} Ukhiya is a rural upazila (subdistrict) in the Cox's Bazar District in the Division of Chattogram, Bangladesh. As of the 2011 census, Ukhiya has a population 207 379 and a total area³⁸ of 261.8 km² and ranks among the lowest for social and economic indicators in the country.³⁷ Moreover, the area is particularly vulnerable to natural disasters. The region is characterized by a tropical monsoon climate with a rainy season from June to mid-October.^{39,40} Common income-generating activities for men include labor jobs in brickfields, wharfs, and construction, followed by driving, fishing, salt business, and agriculture.³⁷ Food insecurity is common, with 34.1% and 46% of households in the southernmost upazilas living in moderate and severe food insecurity, respectively.³⁷

Since August 2017, a “humanitarian catastrophe of epic proportions” has unfolded in Cox's Bazar: an estimated 1.2 million Rohingya total have fled state-lead ethnic cleansing and sought refuge in the district. Today, Rohingya refugees outnumber the host community in Ukhiya 2:1.³⁶ The influx has brought distressing economic, environmental, and societal strain and poses a substantial threat to the local health system.^{36,41}

Health services in Ukhiya are coordinated by the Civil Surgeon of the Ministry of Health and Family Welfare. Ukhiya is home to 24 primary health care facilities; these include community clinics, union sub centers, or union health and family welfare centers. Ukhiya is also home to 1 first referral-level upazila health complex.⁴² OptiDiag was implemented in 15 community clinics, 2 union health and family welfare centers, and 2 union sub centers. Action Contre la Faim France has supported the community-based management of acute malnutrition in Ukhiya since 2012.

The most recent under-5 child health and morbidity data from the division reveal basic vaccine coverage at 83.3% and point prevalence of acute respiratory infection and diarrhea at 4.9% and 6.7%, respectively.⁴³ Nutrition surveys conducted in 2014 and 2017 reveal a prevalence of SAM of 2.9% (November 2014) and 1.4% (February 2017).^{44,45}

Burkina Faso

Burkina Faso ranks as the seventh least developed country in the world.⁴⁶ Fada N'Gourma is both a department and a historically important market town located in the Gourma Province in the East Region of the country.⁴⁷ The department is estimated to be home to a population of 470 818.⁴⁸ Fada N'Gourma has a hot, semiarid climate with a rainy season from April to October. The zone is characterized by rain-fed agriculture, livestock rearing, and cross-border trade with neighboring

Ghana, Niger, Togo, and Benin and is generally food secure.⁴⁹

Health services in Fada N'Gourma are coordinated by the health district. As of 2015, Fada N'Gourma is home to 47 primary health care facilities (Centres de Soins et de Promotion Sociale) and 1 regional reference hospital (Centre Hospitalier Régional). OptiDiag was implemented in 9 Centres de Soins et de Promotion Sociale.

The most recent under-5 child health and morbidity data in the region reveal basic vaccine coverage at 68.5% and point prevalence of acute respiratory infections at 2.1%, of diarrhea at 7.9%, and of malaria at 69.3% (diagnosed with a rapid diagnostic test).⁵⁰ A national nutrition survey conducted in September 2016 revealed an SAM prevalence (95% confidence interval) by WHZ and/or edema of 2.4% (1.4–4.3) and by MUAC of 0.6% (0.3–1.3) in the East Region of the country; another survey conducted in September to October 2018 revealed a SAM prevalence (95% confidence interval) by WHZ and/or edema of 0.9% (0.3–2.4) and by MUAC of 0.5 (0.1–3.5) in the Gourma Province.^{51,52}

Liberia

Liberia ranks as the ninth least developed country in the world.⁴⁶ Monrovia, the country's capital, is home to 1 181 241 inhabitants living across⁵³ 580 km². The climate is tropical, with a rainy season from May to November.⁵⁴ Monrovia are largely engaged in informal small and

micro business.⁵⁴ Monrovia was devastated by the First and Second Liberian Civil Wars and never recovered. Today, most of the capital's basic infrastructure remains in disrepair, and social provisions are grossly inadequate.⁵⁴ Even before the 2013–2014 West African Ebola outbreak, extensive analyses characterized the Liberian health workforce as weak.⁵⁵ On June 9, 2016, Liberia was the last of the 3 countries to be declared Ebola free, but by that time, the scale of the epidemic had completely decimated the health system.⁵⁶

Health services in Greater Monrovia are coordinated by the Montserrado County Health Team. As of 2012, the city is home to 13 primary health centers, 13 clinics, and 9 hospitals. OptiDiag was implemented in 2 health centers and 1 hospital. Action Contre la Faim France has supported the community-based management of acute malnutrition in Monrovia since 2009.

RECRUITMENT PROCESS

Participants were included in the study based on a rhythmic recruitment process in each country: children with SAM were included in consecutive blocks of 12 (4 patients in each anthropometric phenotype at a time per country). A patient was eligible for recruitment in the ongoing recruitment block only if the quota of 4 patients for this phenotype had not yet been reached, and each block had to be filled before moving to the next one. In doing this, we ensured an equal representation of anthropometric phenotypes over the 1-year implementation period to account for seasonal variability.

ANTHROPOMETRIC MEASUREMENTS

Anthropometric measurements were taken in duplicate and followed standard WHO recommendations for children in this age group.^{11,12} Weight was measured by using either a seca

hanging scale or a mother-infant scale to the nearest 100 g in children either undressed or wearing light underwear. Length or height (change of measuring position at 2 years) was measured by using a standard United Nations Children's Fund measuring board to the nearest 1 mm. MUAC was measured on the left arm with a standard MUAC tape to the nearest 1 mm. Sitting length or height was measured as described elsewhere.⁵⁷

BIOCHEMICAL THRESHOLDS

The thresholds for defining abnormal biochemical parameters in blood were as follows: α -1-acid glycoprotein level >1 g/L⁵⁸; C-reactive protein level >5 mg/L⁵⁸; adjusted ferritin level <12 μ g/L¹⁵; unadjusted ferritin level <12 μ g/L or <30 μ g/L in the presence of infection^{59,60}; sTfR level >8.3 mg/L⁶¹; and adjusted and unadjusted RBP levels ≤ 0.7 μ mol/L and ≤ 1.05 μ mol/L for vitamin A deficiency and vitamin A insufficiency, respectively.^{62,63}

STATISTICAL ANALYSES

Bivariate and multivariate logistic regression were used to examine the associations between each significant feature and the odds of being in one diagnostic group compared with the other; quantile, or median, regression was also used for continuous variables to account for skew.⁶⁴ Confounding and/or effect modification by age (± 24 months), sex, stunting (HAZ ± -2), and sitting/standing ratio was assessed; we computed sitting/standing ratio and generated individual z scores (SSRZ) as described elsewhere.⁵⁷ SSRZ was dichotomized to identify children with longer legs (SSRZ in the lower tertile versus SSRZ in the upper 2 tertiles). Adjusted models included any or all the aforementioned covariates when confounding (magnitude of confounding $\geq 20\%$) or interaction (Cochran-Mantel-Haenszel test, $P < .05$) was detected. Variance

inflation factors were used to quantify multicollinearity, and then covariates in adjusted models were removed to reduce it (variance inflation factor <3). The performance of the resulting adjusted models was evaluated for statistical improvement, compared with the unadjusted alternative (Hosmer-Lemeshow goodness-of-fit test, $P < .05$), when the significance of the independent variable of interest was either lost or gained.

To determine if a multilevel modeling approach was necessary to control for country-level cohort effects, we examined intraclass correlation coefficients and found that it was not; however, a country variable was included in all adjusted models as either a covariate (to account for residual confounding) or an interaction term (when effect modification was detected). Correction for multiple testing was applied by using a step-up false discovery rate method. All analyses were performed by using Stata version 13 (Stata Corp); P values $< .05$ were considered statistically significant.

SUPPLEMENTAL TABLE 6 Supplementary Clinical Characteristics at Admission

	Patients by Anthropometric Category			<i>P</i> ^a
	WHZ Only (<i>n</i> = 138)	Both WHZ and MUAC(<i>n</i> = 152)	MUAC Only(<i>n</i> = 161)	
Eye infection	1 (2/136)	1 (2)	1 (2/160)	.99
Bitot spots	1 (1)	1 (2)	1 (1)	.78
Tachycardia	7 (9)	5 (8)	6 (9)	.89
Hypothermia (<36.0°C)	4 (5)	5 (8)	2 (4)	.43

Values are % (*n*).

^a For 3-group comparison (WHZ only, both WHZ and MUAC, and MUAC only) by Pearson's χ^2 tests (or Fisher's exact tests for small sample sizes) for categorical data and Kruskal-Wallis tests for skewed continuous data.

SUPPLEMENTAL TABLE 7 False Discovery Rate Corrected Unadjusted and Adjusted Median Serum Leptin and Serum Ferritin by Comparison

	Comparison 1				Comparison 2				Comparison 3						
	Low WHZ Only		Low MUAC Only		Low MUAC Only		Both WHZ and MUAC		Low WHZ Only		All Low MUAC				
	Median	95% CI	Median	95% CI	Median	95% CI	Median	95% CI	Median	95% CI	Median	95% CI	P		
Serum leptin, pg/mL															
Unadjusted median ^a	215.8	122.0–346.6	331.5	159.0–560.1	.002	331.5	159.0–560.1	180.1	87.7–346.8	<.001	215.8	122.0–346.6	245.8	117.0–482.0	.21
Adjusted median	232.1	193.9–263.0	372.8	226.4–380.0	.005	352.0	229.8–414.3	217.6	133.2–238.0	<.001	220.1	193.9–309.0	282.0	223.0–331.4	.21
Serum ferritin, µL/L															
Unadjusted median ^a	27.7	8.8–48.4	33.6	15.9–54.3	.06	33.6	15.9–54.3	34.0	16.4–67.7	.49	27.7	8.8–48.4	33.9	16.1–60.2	.03
Adjusted median	31.9	7.1–34.4	32.9	24.0–51.0	.83	31.1	27.4–34.9	34.3	30.6–38.6	.40	22.3	18.3–26.7	33.8	33.3–37.8	.03

Adjusted for age, sex, stunting, SSRZ, and country. CI, confidence interval.

^a The Wilcoxon rank test is used to test for equality of medians when the unadjusted median is presented.

SUPPLEMENTAL TABLE 8 False Discovery Rate Corrected, Unadjusted Bivariate Logistic Regression Analysis by Comparison

	Comparison 1: WHZ Only Versus MUAC Only			Comparison: Both WHZ and MUAC Versus MUAC Only			Comparison 3 All MUAC Versus WHZ Only		
	UOR	95% CIs	P	UOR	95% CIs	P	UOR	95% CIs	P
Biochemical features									
Iron deficiency									
Body iron stores <0 mg/kg body weight	2.11	1.15–3.88	.03	1.29	0.68–2.43	.87	0.54	0.32–0.90	.02
Adjusted serum ferritin level <12 µg/L	1.89	1.09–3.28	.02	0.97	0.54–1.74	.91	0.52	0.32–0.84	.01
Urinalysis									
Bilirubinuria, ≥15 µmol/L (1 mg/dL)	3.88	1.36–11.05	.02	3.67	1.29–10.45	.03	0.59	0.29–1.18	.13
Leukocyturia, ≥25 leukocytes per µL	0.55	0.25–1.21	.14	1.52	0.77–2.99	.23	2.29	1.14–4.58	.04
Clinical features									
Slow or very slow skin pinch	4.65	1.48–14.60	.03	6.26	2.06–19.01	.005	0.73	0.36–1.47	.59
Sunken eyes	2.82	1.37–5.78	.02	2.58	1.27–5.24	.01	0.61	0.35–1.06	.30
Restlessness and/or irritability	2.64	0.66–10.55	.21	6.04	1.70–21.46	.01	1.27	0.51–3.15	.70
WHO IMCI recommendations: some or severe dehydration	3.29	1.22–8.83	.05	4.29	1.65–11.11	.008	0.76	0.39–1.50	.59
Dermatosis	1.18	0.51–2.72	.69	2.68	1.31–5.51	.01	1.49	0.76–2.95	.53
Clinical iron deficiency									
Conjunctival and/or palmar pallor	1.42	0.86–2.33	.21	1.91	1.19–3.08	.01	0.98	0.64–1.50	.98
Malaria	0.33	0.16–0.68	.02	0.59	0.32–1.08	.10	2.39	1.21–4.74	.59
Visible severe wasting									
Visible ribs	1.80	1.00–3.26	.10	2.82	1.53–5.18	.05	0.61	0.35–1.06	.30
Loose skin on arms or thighs	1.59	0.74–3.39	.27	3.54	1.76–7.11	.005	1.27	0.51–3.15	.70
Visible back ribs or shoulder bones	1.65	0.92–2.94	.15	2.64	1.47–4.73	.005	0.76	0.39–1.50	.60
Flesh missing or folds of skin on buttocks and/or baggy pants	1.84	0.43–7.95	.44	6.50	1.84–22.96	.008	1.93	0.70–5.32	.52
WHO IMCI recommendations: severe or extreme wasting	1.53	0.84–2.77	.21	2.52	1.36–4.67	.008	1.01	0.59–1.71	.98
Recent health and nutritional histories (caretaker reported)									
Health status deterioration	1.76	1.09–2.84	.045	1.74	1.08–2.79	.03	0.77	0.51–1.16	.52
Any 1 ^a	1.87	1.13–3.08	.044	1.55	0.96–2.49	.08	0.66	0.42–1.03	.30
Any 2 ^b	1.96	1.23–3.11	.024	1.35	0.86–2.11	.19	0.59	0.40–0.89	.17 ^c

CI, confidence interval.

^a Any 1 of the following: eaten a lot less or quite a lot less food, much less or a great deal less healthy than usual, and lost a lot or quite a lot of weight.^b Any 2 of the following: eaten a lot less or quite a lot less food, much less or a great deal less healthy than usual, and lost a lot or quite a lot of weight.^c No longer statistically significant after false discovery rate correction.

SUPPLEMENTAL TABLE 9 False Discovery Rate Corrected, Adjusted Multivariate Logistic Regression Analysis by Comparison

	Comparison 1: WHZ Only Versus MUAC Only			Comparison 2: Both WHZ and MUAC Versus MUAC Only			Comparison 3: All MUAC Versus WHZ Only		
	aOR	95% CIs	P	UOR	95% CIs	P	aOR	95% CIs	P
Biochemical features									
Iron deficiency									
Body iron stores <0 mg/kg body weight	2.25	1.10–4.60	.03	1.29	0.68–2.44	.86	0.50	0.28–0.90	.02
Adjusted serum ferritin level <12 µg/L	2.13	1.11–4.09	.03	0.97	0.54–1.75	.92	0.35	0.21–0.60	<.001
Urinalysis									
Bilirubinuria, ≥15 µmol/L (1 mg/dL)	2.51	0.67–9.36	.17	3.96	1.38–11.42	.02	0.61	0.31–1.24	.17
Leukocyturia, ≥25 leukocytes per µL	0.55	0.25–1.21	.17	1.46	0.73–2.91	.29	1.77	0.86–3.66	.17
Clinical features									
Slow or very slow skin pinch	9.47	2.07–43.25	.03	6.36	2.09–19.35	.003	0.74	0.37–1.48	.82
Sunken eyes	2.88	1.22–6.76	.06 ^a	2.58	1.25–5.34	.012	0.57	0.32–1.00	.31 ^b
Restlessness and/or irritability	1.78	0.42–7.52	.60	6.72	1.86–24.30	.006	1.06	0.41–2.76	.96
WHO IMCI recommendations: some or severe dehydration	2.51	0.90–6.97	.20	4.29	1.65–11.12	.005	0.76	0.39–1.49	.82
Dermatosis	1.25	0.54–2.92	.65	2.68	1.29–5.60	.004	3.43	0.95–12.46	.31
Clinical iron deficiency									
Conjunctival and/or palmar pallor	1.42	0.86–2.33	.31	1.93	1.20–3.12	.01	0.99	0.65–1.52	.97
Malaria	0.24	0.10–0.56	.02	0.58	0.31–1.06	.09	2.34	1.18–4.65	.23 ^b
Visible severe wasting									
Visible ribs	2.44	0.73–8.20	.31	10.00	2.71–36.85	.002	0.59	0.20–1.74	.82
Loose skin on arms or thighs	1.78	0.74–4.27	.31	3.66	1.81–7.40	.002	1.13	0.60–2.11	.89
Visible back ribs or shoulder bones	2.88	1.07–7.81	.11	8.36	2.98–23.44	<.001	0.79	0.32–1.91	.89
Flesh missing or folds of skin on buttocks and/or baggy pants	2.04	0.46–9.00	.52 ^b	6.46	1.81–23.02	.006	1.25	0.43–3.63	.89
WHO IMCI recommendations: severe or extreme wasting	2.28	0.68–7.71	.65	9.17	2.48–33.87	.003	0.64	0.21–1.95	.82
Recent health and nutritional histories (caretaker reported)									
Health status deterioration									
Any 1 ^c	1.29	0.53–3.15	.65	1.55	0.93–2.58	.09	0.86	0.40–1.88	.90
Any 2 ^d	1.13	0.55–2.36	.74	6.12	2.17–17.27	.002	0.93	0.52–1.66	.92

Adjusted for age, sex, stunting, SSRZ, and/or country. aOR, adjusted odds ratio; CI, confidence interval.

^a Marginally statistically significant ($.05 \leq P < .1$) after false discovery rate correction.

^b No longer even marginally statistically significant after false discovery rate correction ($P \geq .1$).

^c Any 1 of the following: eaten a lot less or quite a lot less food, much less or a great deal less healthy than usual, and lost a lot or quite a lot of weight.

^d Any 2 of the following: eaten a lot less or quite a lot less food, much less or a great deal less healthy than usual, and lost a lot or quite a lot of weight.

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