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Jose Cuesta and Laura Maratou-Kolias

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CHILD UNDERNOURISHMENT, WASH AND POLICY SYNERGIES IN TUNISIA: PUTTING NUMBERS INTO UNICEF'S CONCEPTUAL FRAMEWORK OF NUTRITION

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Abstract: This paper develops an econometric strategy to operationalize the United Nations Children's Fund (UNICEF's) conceptual framework for nutrition, estimating the effects on child stunting that additional investments in water, sanitation, and hygiene (WASH) *intervention packages* have across population groups (poor and non-poor) and residence (urban and rural). Moving away from estimating *single intervention* marginal returns, the empirical framework is tested in Tunisia; a country with notable but uneven progress in child nutrition. A successful reduction of stunting will involve mapping the distinctive most effective intervention packages by residence and socioeconomic status, moving away from universal policies.

Key words: Stunting, WASH, Synergies, UNICEF framework, Tunisia

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JEL classification: I38, I15

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1. INTRODUCTION

Chronic low-height-for-age – or stunting – causes irreversible damage to children's growth, health and cognitive development, resulting in a host of undesired impacts. These range from higher child mortality and morbidity and higher risk of chronic disease in adulthood, to lower school results, reduced adult work productivity, and lower future earnings (Alderman, Hoddinott and Kinsey, 2006; Alderman et al. 2013; Christiaensen and Alderman, 2004; Deolalikar, 2008; Glewwe, Jacoby and King, 2001; Hoddinott and Kinsey 2001; Maccini and Yang 2009; Mahmud and Mbuya, 2015; Strauss and Thomas, 1998; Victoria et al. 2008).

It is also long-known that the determinants of nutrition are multi-dimensional and that solutions to chronic undernourishment require multi-sector approaches (Alderman et al. 2013; Food and Agriculture Organization of the United Nations [FAO], 2011; Haddad et al. 2003; *Lancet*, 2013; Prentice et al. 2013; Riely et al. 1999; World Food Programme [WFP], 2009; Save the Children, 2012; Scaling Up Nutrition, 2012; Skoufias, 2016; United Nations Children's Fund [UNICEF], 1990).

Because of its multi-sectoral nature, strong synergies among numerous determinants need to emerge before real progress in nutritional status takes place, especially for those critical first 1,000 days in the life of a child. In practice, improvements in stunting come from the successful integration of nutrition interventions – such as fortification of foods, promotion of breastfeeding, therapeutic foods benefiting undernourished children – along with interventions from other sectors, such as childcare programmes for working mothers, improvements in agriculture productivity, and the strengthening of safety nets, among others (Scaling Up Nutrition, 2012).

Water, sanitation, and hygiene (WASH) interventions constitute another necessary dimension to improving child nutrition. The original UNICEF framework for nutrition recognized this conceptually. The international community politically committed to promoting WASH interventions to improve nutrition during the second International Conference on Nutrition (ICN2), in 2014 (FAO and World Health Organization [WHO], 2014; WHO, 2015).

Empirically, multiple studies report positive returns to children's nutritional status from the provision of clean water and modern sewerage systems (Barrera, 1990; Behrman and Deolalikar, 1990; Behrman and Wolfe, 1984; Cuesta, 2007; Glewwe, 1998; Haddad and Hoddinott, 1990; Horton, 1986; Keller, 1988; Skoufias, 1999, 2016; and Webb and Block, 2004). More recent research focused on identifying concrete and direct pathways between WASH and nutrition (Fanzio, 2014; and, for a detailed review, Chase and Ngure, 2016). For example, improved nutrition can be attained through reduction in diarrheal disease due to declines in faecal contamination of the environment; reduced exposure to enteric infections; infections with protozoa and helminths; reduced prevalence of anaemia; and reduced time spent fetching water and caring for sick children. In fact, it is estimated that WASH explains as much as 35 per cent of the variation in stunting rates across countries over time (Smith and Haddad, 2014). Furthermore, new evidence on the effect of open defecation on malnutrition (Hammer and Spears, 2016) – confirms earlier findings linking nutrition and WASH.

This is hardly surprising. What is less known, however, is that evidence also suggests that WASH effects on nutrition are not typically uniform. Instead, they vary by age group and maternal education level, and are not always significant. Indeed, the direction and significance of such interactions is a matter for empirical study. Bringing together the dominant conceptual framework on child nutrition and existing empirical evidence allows us to draw two key conclusions. First, sector-specific interventions alone are often not sufficient to solve complex, interrelated, and multidimensional nutritional challenges.[1] Second, in most cases, neither are policies that do not account for the specific needs of different types of households, locations, and vulnerability.

Is it therefore justified to continue investing in WASH across the board when such investments do not always provide the expected returns in terms of improving child nutrition? Under what circumstances should we invest additional funds in WASH with expectations of improving child nutrition? These are particularly important questions when designing effective policy interventions in a world that aspires to end hunger, improve nutrition, and ensure sustainable management of water and sanitation by 2030 – aspirations enshrined in the new Sustainable Development Goals 2 and 6. Of course, it is well acknowledged that there are other reasons to invest in WASH that go beyond improving nutrition; for example, expanding coverage and/or ensuring the reliable supply of a critical public service; addressing gender violence; and reducing political instability (Hunter et al., 2016).

This analysis addresses the issue of investments in WASH by following a logic of economic efficiency, that is, by estimating which interventions have the largest impact on improving child nutrition.

We acknowledge from the start that a simplistic approach is most likely to be unsatisfactory in a context of multiple and interrelated factors. For this reason, we propose an extension of UNICEF's conceptual framework to econometrically quantify which, among the multiple sets of interventions or policy packages, produce the most effective synergies towards reducing stunting. In other words, we estimate the integrated impacts or synergies of multiple interventions rather than the single impact of a given intervention. From a policy perspective, this approach provides more useful insights for policy-making than evidence obtained from a single sector. Moreover, it provides an estimate of the magnitude of the nutritional impact that specific interventions have within an integrated delivery of services.

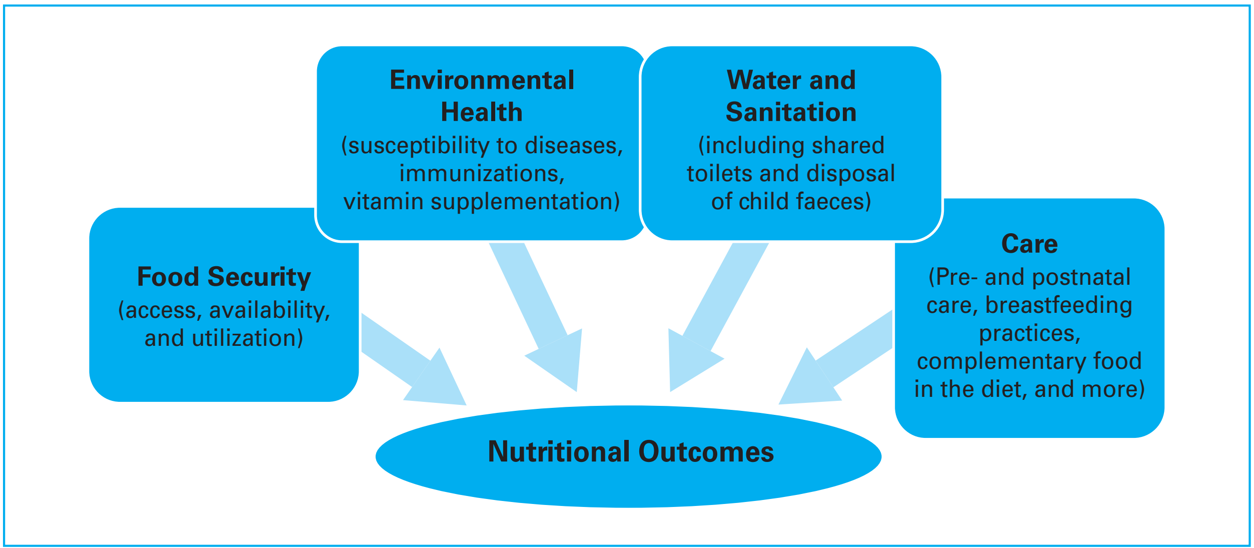
Section 2 explains this methodological extension. Section 3 introduces a specific country case application in Tunisia, where the new analytics are tested. Section 4 reports key estimates and discusses main results. Section 5 provides concluding remarks with a view to policy design.

[1] In some cases, WASH-specific programmes may have an impact on health and nutrition. One example are community-led participatory approach sanitation programmes that have proven successful in mobilizing communities to build their own toilets and stop open defecation. A case in point is the Community-led total sanitation, CLTS, programme in Mali. (Pickering et al. 2015).

2. THE SYNERGIES EXTENSION OF UNICEF'S CONCEPTUAL FRAMEWORK FOR NUTRITION

In 1990, UNICEF developed a conceptual framework for nutrition that is particularly relevant to the analysis of synergies among public interventions. UNICEF's framework emphasizes the roles that food security, environmental health, and childcare practices play in child nutrition approximated in our study by stunting rates among children from birth to age five (Figure 1).[2] This framework suggests that increases in access to, or use of only one of these factors, do not compensate for inadequate levels of other factors. This implies that policies that improve food security alone cannot decrease undernutrition if, for example, the community does not have adequate levels of safe water and sanitation or pre-natal health services.

Figure 1 - ***Integrated Multisectoral Interventions for Appropriate Child Nutrition***



Source: Adapted from UNICEF (1990).

Against this widely agreed conceptual background, our notion of synergies is operationalized as follows: We estimate a single equation that links adequacies to basic services (*As*) with the nutritional status or stunting of children, captured by the height-for-age Z (HAZ) score. The focus is not merely access to or use of basic services, but, rather, *adequate* access to such services. This enhanced notion provides a sense of quality to services that is not present when looking at access or use alone. For example, food adequacy implies more than access to sufficient food to cover minimum caloric requirements, but also requires access to a balanced, diverse, and affordable diet. Similarly, adequate water access goes beyond accessing a source of safe water; it implies a continuous, predictable, and affordable supply of water. Section 3 discusses concrete definitions of adequacies in more detail.

[2] Food security measures the availability and consumption of various foods. Environmental health measures the child's susceptibility to diseases due to lack of improved infrastructure (such as sanitation and drinking water) or lack of preventive health measures taken. Care measures the quality of care provided by the caregiver based on feeding and hygiene practices adopted and by the availability of the caretaker. Furthermore, this measure includes the extent to which caregivers are supported in their child-rearing endeavours.

Specifically, the equation to be estimated is:

$$HAZ = \alpha + \sum_{i=1}^{4} (\beta * A)_i + \sum_{i,j=1}^{4} \gamma_{ij} (A_i * A_j) + \sum_{i,j,k=1}^{4} \gamma_{ijk} (A_i * A_j * A_k) + \gamma_{1234} (A_1 * A_2 * A_3 * A_4)$$

$$HAZ_i = \alpha + \beta_1 A_1 + \beta_2 A_2 + \beta_3 A_3 \quad (1)$$

where HAZ_i is the HAZ score for child i, and where i, j, k = 1…4 denotes each of the four dimensions considered, i.e. food; water and sanitation; environmental health; and care. Thus, A_i denotes access to each of the four adequacies for each child i: A_1 is 1 when the household has adequate food (F) (0 otherwise); A_2 is 1 when the household enjoys adequate environmental health (H) (0 otherwise); A_3 is 1 when the household has adequate water and sanitation (W) (0 otherwise; and A_4 is 1 for households with adequate care (0 otherwise).

These measures are independent of whether the child has access to each of the other three adequacies. In this specification, the constant term provides an estimate of the mean value of HAZ scores for children without access to adequate food security (A_1= 0), environmental health (= 0), water and sanitation (A_3=0), and care (A_4= 0). That is, the constant term captures $E\ HAZ \mid X = x$) or the expected (or mean) value of height-for-age, conditional on a control variable X, when none of the adequacies are met – with the assumption that $E\ (\varepsilon_i \mid A_1, A_2, A_3, A_4) = 0$:

$$E\ (HAZ_i \mid A_1=0, A_2=0, A_3=0, A_4=0) = \alpha \quad (2)$$

The coefficient β_1 in (1) yields an estimate of the increase in the mean HAZ score for children who have access to adequate food security (A_1=1), but do not have access to adequate environmental health (A_2=0), adequate water and sanitation (A_3=0), or access to adequate care (A_4=0). The reference group is the group of children satisfying no adequacies, i.e. the mean HAZ score for the reference group summarized by the constant term. The coefficients β_2, β_3, and β_4 have analogous interpretations for environmental health, water and sanitation, and care, respectively. The coefficients γs yield estimates of synergies or complementarities from having access to more than one determinant of nutrition. Specifically, the mean HAZ score for children with access to adequate food security (A^1=1) and adequate environmental health (A_2=1), is summarized by the expression:

$$E\ (HAZ_i \mid A_1=1, A_2=1, A_3=0, A_4=0) = \alpha + \beta_1 + \beta_2 + \gamma_{12} \quad (3)$$

Thus, the mean value of HAZ scores for children in households with access to adequate food security and adequate environmental health can be considered as consisting of the sum of three components: the first component is the increase in HAZ scores associated with children in households with adequate food security only (β_1); the second component (β_2), is the increase in HAZ scores associated with children in households with adequate environmental health only; and the third component (γ_{12}) is the increase in HAZ scores associated with children in households that have access to both adequate food security and adequate environmental health. The coefficient γ_{12} yields information on whether there are additional (extra) gains (or losses) in HAZ scores derived from joint access to adequate food and health compared to exclusive access to adequate food and exclusive access to adequate health. A significant and positive value of the coefficient γ_{12} implies synergies from the simultaneous access to adequate food security and adequate environmental health, in the improvement of child nutrition.

In sum, this strategy allows us to quantify which synergies are more impactful in reducing child undernutrition. It goes beyond progress *within* specific sectors, instead prioritizing simultaneous progress *across* sectors. Ultimately, this strategy complements UNICEF's conceptual justification for multi-sectoral interventions.

3. A COUNTRY CASE STUDY: TUNISIA

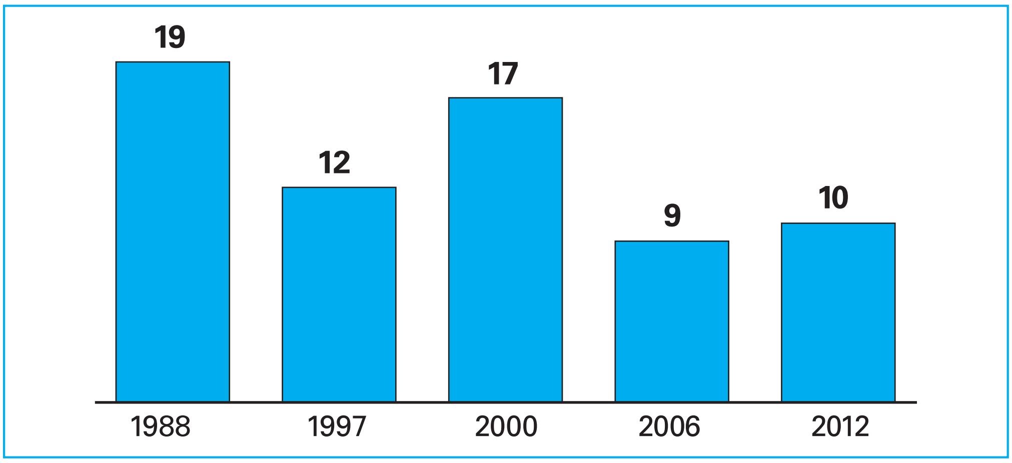
3.1 Why Tunisia?

With prevalence levels around 1 per cent, Tunisia has long achieved the Millennium Development Goal Target 1C to halve, between 1990 and 2015, the proportion of people suffering from undernourishment. Most recent statistics specific to children's nutritional status report low birth weight incidence at 7 per cent; moderate and severe underweight at 2 per cent; moderate and severe stunting at 10 per cent; and moderate and severe wasting at 3 per cent for 2008–12 (UNICEF, 2014).

These numbers suggest that Tunisian children's nutritional status is better than the average found in the Middle East and North Africa (MENA) region, which averages at 7 per cent, 18 per cent and 8 per cent respectively, for moderate and severe underweight, stunting, and wasting. Practices including introduction of breastfeeding and semisolid and soft foods, as well as consumption of iodized salt, all place Tunisia among the best performers in that region - for countries for which information is available.[3]

However, the nutritional challenges in Tunisia do not relate to levels but to uneven progress. Improvements in stunting among Tunisian children are neither steady nor sustained over time, as indicated in Figures 2 and 3. Stunting prevalence for the under-five age group has experienced frequent swings, on occasions large in magnitude, and is in many cases increasing – a relatively new pattern, which might be partially related to the recent international food price crises. In addition, socioeconomic differences among stunted children prevail: the stunting levels of children in the poorest quintile (of wealth) are double those of the richest quintile (Figure 3, page 11). Consequently, notwithstanding its achievements, Tunisia still has to work on eradicating child malnutrition and sustaining its progress over time.

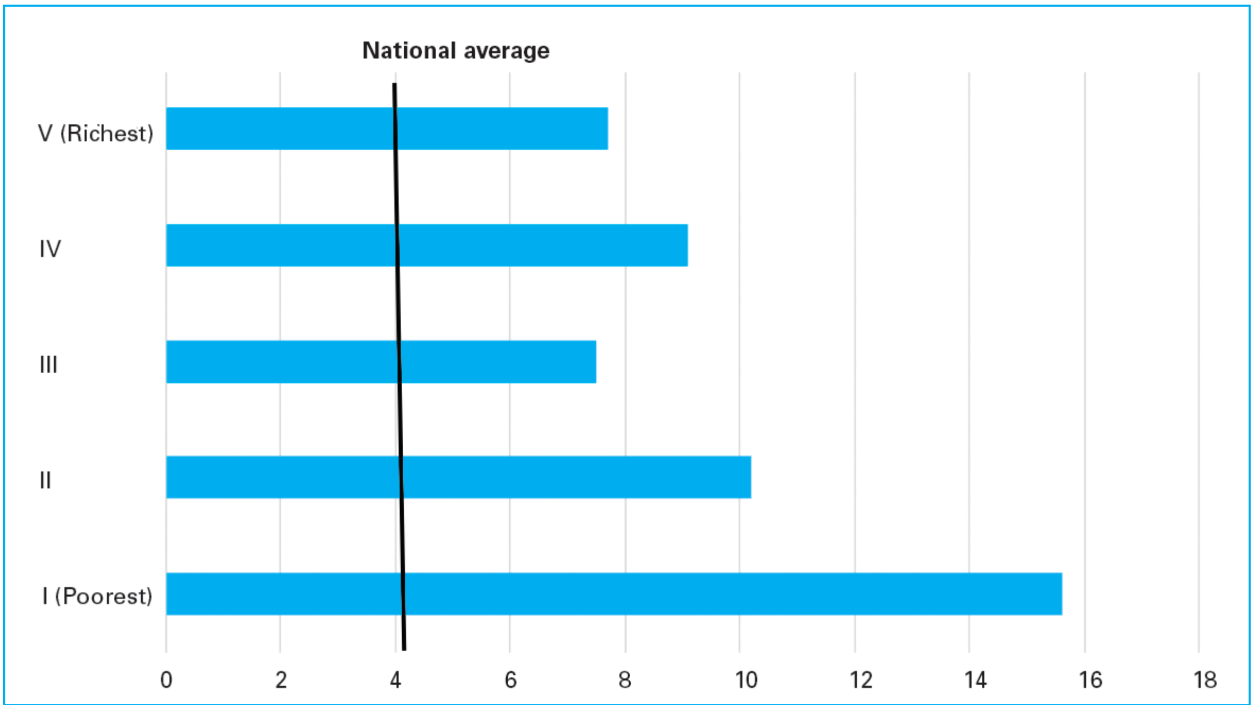
Figure 2 - ***Prevalence of Under-Five Stunting in Tunisia, 1988–2012 (%)***



Source: UNICEF (2014).

[3] Other nutritional indicators, however, such as moderate and severe overweight or prevalence of anaemia among women at reproductive age are not so favourable, and remain short of international targets (i.e. the Global World Health Assembly targets, as reported in International Food Policy Research Institute [IFPRI], 2014).

Figure 3 - ***Stunting by Wealth Quintiles in Tunisia, 2011–12***



Source: UNICEF (2014), based on MICS 2011–12 for Tunisia.
Note: As the percentage of children under age five who are stunted, by wealth index quintile. Stunting is defined as having a height-for-age more than -2 standard deviations (SD) below the median of the World Health Organization (WHO) reference.

3.2 WASH in Tunisia

Tunisia's achievements in WASH access and adequacy lag behind nutrition. Table 1 (page 12) shows coverage rates for several WASH services taken separately, as well as adequacy rates for specific WASH services. For this purpose, we compute response categories for improved WASH facilities based on standard UNICEF/WHO/Joint Monitoring Programme (JMP) definitions for monitoring access to improved facilities. We also assess whether the household safely disposes of children faeces and whether the households' use of toilets is shared. More comprehensive and demanding definitions of adequacy are not possible in the case of Tunisia due to data limitations (see section 4.2).

When looking at the country as a whole, the first two rows of Table 1 confirm high levels of improved water and sanitation, in excess of 91 per cent, with the urban population at close to universal access. However, poverty status is a strong predictor of a more limited access to improved water or sanitation services (around 89 per cent of access to improved water and 82 per cent for improved sanitation). Evidence shows that the urban poor tend to have much higher access rates than the rural poor – a difference of more than 12 percentage points in both water and sanitation services, and even higher access rates than those reported by the rural population as a whole.

When adequacy components are taken into consideration, coverage rates significantly decline. Piped improved water and safe sanitation in the form of use of sewage and septic tank sanitation are enjoyed by significantly fewer Tunisians, especially if they are poor and reside in rural areas

(41 and 35 per cent, respectively). The consideration of the type of toilet facility, concretely, whether or not is shared, also affects the levels of coverage, but much less than the safe disposal of child faeces. In fact, the most influential WASH-related behaviour observed in the MICS is the safe disposal of child faeces. This practice is by far the least common among all household groups analyzed: the full sample shows a rate of 2 per cent, with the urban poor having the highest rate of 6 per cent across population groups.

When looking at WASH services jointly, the last two rows of Table 1 show different definitions of what could be considered adequate integrated WASH services. Adequacy under definition 1 includes only having access to improved water, improved sanitation, and a private toilet. The second definition also requires the safe disposal of child faeces in addition to the previous services. Under adequacy definition 1, only 82 per cent of Tunisians are considered to have adequate WASH services, and most of Tunisians with inadequate services are poor (55 per cent adequacy) or rural (63 per cent adequacy). When fecal disposal and toilet sharing are jointly taken into account, adequacy rates plummet to close to zero across all groups considered (about 2 per cent). The poor, rural poor and urban poor groups have the highest adequacy rate at only 3 per cent, and among all the other categories analyzed, the adequacy rates are at – or below – 2 per cent.

Table 1 - ***WASH-Poverty Profiles Using Adequate Access Rates, 2011–12 (%)***

	Full sample	Urban	Rural	Poor	Non-poor	Rural poor	Urban poor
All improved water	96.0	100.0	89.0***	87.0	98.0***	84.0	96.0***
All improved sanitation	91.0	97.0	82.0***	70.0	98.0***	66.0	86.0***
Piped improved water	59.0	63.0	53.0***	46.0	63.0***	41.0	65.0***
Sewage and septic tank sanitation	79.0	95.0	54.0***	42.0	91.0***	35.0	68.0***
No shared toilet use	94.0	97.0	90.0***	83.0	98.0***	81.0	90.0***
Child faeces disposed of safely	2.0	2.0	2.0	4.0	2.0***	3.0	6.0***
DEF 1: All improved water, all improved sanitation, no shared toilet use, no child faeces considered	82.0	94.0	63.0***	55.0	91.0***	49.0	79.0***
DEF 2: All improved water, all improved sanitation, no shared toilet use, and child faeces disposed of safely	2.0	2.0	2.0	3.0	2.0**	3.0	3.0*

Source: Authors' estimates based on MICS 2011–12.

Notes: Poor and non-poor are defined on the basis of the wealth quartiles, with those households belonging to the first quartile identified as poor. ***,**, and * refer to statistical significance levels of 1, 5, and 10 per cent, respectively, on a test of means across categories immediately to the right. Thus, tests reported in the rural category compare urban versus rural coverages for each definition used. Significance levels in the non-poor column compare poor and non-poor coverage rates.

4. APPLYING THE SYNERGIES EXTENSION TO UNICEF FRAMEWORK IN TUNISIA

4.1 Linking WASH and Nutrition Sectors in Tunisia

In Tunisia, the most recent comprehensive survey with nationally representative anthropometric measures and other health data is the 2011–12 Multiple Indicator Cluster Survey (MICS) conducted by UNICEF, the National Institute of Statistics, and the Ministry of Development and International Cooperation of Tunisia. The main purpose of the 2011–12 MICS dataset is to track progress toward the Millennium Development Goals (MDGs) and, more recently, the Sustainable Development Goals (SDGs). It includes sections on health, nutrition, education, child protection, WASH, HIV/AIDS, and access to information technology.

In addition to measures of height and weight for children under five years old, the survey collects feeding practices for infants, immunization history for children, food consumed in the last 24 hours for children under three years old, detailed information on health access, water and sanitation variables, and other socio-economic information about the household and its members.
The 2011–12 MICS is representative at the national, urban/rural, and regional level for households, women aged 15–49, and children under 5 years of age. In addition, the survey provides a pre-calculated wealth index as a proxy for poverty.

From the 2011–12 MICS, it is possible to construct several definitions of adequacy, as discussed in the previous section. Despite the two definitions already adopted in Tunisia, there is, in practice, a gap between the ideal or desired definitions of adequacy and feasible definitions of adequacy from the data available. Table 2 (page 14) compares ideal definitions of adequacy for all dimensions considered in UNICEF's framework, with information available in the 2011–12 Tunisian MICS.

This comparison highlights the gap between ideal and feasible definitions of adequacy in Tunisia, especially within the food and care dimensions. In the case of WASH, the definition of adequacy can be adjusted to account for several criteria, following the WHO/UNICEF JMP recommendation to include improved sources of water and sanitation, non-shared toilet facilities, and safe disposal of child faeces. Another variable of interest – hygienic hand-washing practices – is captured in the MICS, but its incidence is very low (less than 70 observations). This discourages its use in the empirical analysis.

4.2 Effects of Adequate Access to WASH on Child Nutritional Status

Table 3 (page 17) reports the effects of food-, health-, WASH-, and care-related interventions on child nutritional status. In so doing, it uses the HAZ score as the dependent variable capturing child malnutrition on a sample of children aged 0–24 months (the only age group for which MICS reports breastfeeding and prenatal variables). As indicated here, each of these dimensions has individual and interaction effects that are reported separately. For example, the coefficient "adequate in WASH only" captures the effect – correlation – on Tunisian children's nutritional status of successfully reaching adequate access to WASH services. In other words, this effect quantifies the nutritional benefit of providing adequate access to WASH to all those Tunisian households that currently lack it.

Table 2 - ***Ideal and Feasible Definitions of Adequacy for Child Nutrition in Tunisia***

Ideal adequate care based on UNICEF framework	Is it available in the 2011–12 MICS?
Maternal education, knowledge, and beliefs	Available, but no international consensus on appropriate thresholds
Workload and availability of caregiver	Not available
Social support for caregiver	Not available
Psychosocial care	√
Caring behaviours: Breastfeeding	√ MICS details whether breastfeeding was exclusive during first six months; within one hour of birth; continued breastfeeding
Health seeking	Available, but no international consensus on appropriate thresholds
Complementary feeding	√
Hygiene	Soap has been reported as available for hand-washing, but very few observations
Child feeding index	Not available
Ideal adequate food (food security dimension)	
Household dietary diversity score	Not available
Children's dietary diversity score (CDDS)	√ With sufficient differentiation of food groups and meal frequency to calculate CDDS
Women's dietary diversity score	Not available
Minimum acceptable diet (for children aged 6–24 months)	√ A combination of breastfeeding, intake of diverse food, and meal frequency
Food Insecurity Experience Scale	Not available
Household Hunger Scale	Not available
Coping Strategy Index	Not available
Percentage of households that cannot afford a balanced diet	Not available
Relative prices of different food groups	Not available
Percentage of calories from starches	Not available
Percentage of people lacking access to calories	Not available
Ideal adequate water and sanitation	
Access to safe water	√
Access to improved sanitation	√
Community-level sanitation	√
No shared toilets	√
Safe disposal of child faeces	√
Hand-washing hygiene	Very limited number of observations
Ideal adequate environmental health	
Use of prenatal services	√
Age appropriate immunization status	√ (ages 18–29 months only)
Vitamin A supplementation status	Not available
Oral rehydration solutions used for treatment of diarrhoea	Not available
Antibiotic treatment for pneumonia	Not available

Source: MICS 2011–12.

The same effect is estimated for each of the other dimensions considered. Beyond these individual effects, other variables capture the effects of achieving, for instance, WASH adequacy when households benefit from one, two, or three other adequacies. This is the case, for example, of adequate WASH access and adequate food access. Such estimates include the effects of the specific satisfied adequacies – plus the interaction or synergy effects of having achieved these two adequacies. Results specific to WASH adequacies (Table 3, upper panel) are then compared with the correlations estimated for other dimensions that do not include WASH (food, environmental health, and care adequacies (Table 3, lower panel).

Results shown in Table 3 confirm, first and foremost, that improvements in the analysed policy dimensions are not sufficient to lead to large improvements in the nutritional status of Tunisian children. This is likely a reflection of relatively good levels of nutrition at the baseline, on the one hand, and average improvements masking the inequalities that still remain across urban, rural and poor populations, on the other. More concretely, achieving adequacy on any single dimension is not sufficient to make a statistically significant impact on the current nutritional status of children in Tunisia. This is not only true for WASH, but also for food, environmental health, and care. The findings are based on samples of poor, non-poor, urban, and rural households. Estimates not reported here are also generated across quartiles of household wealth, both across urban and rural settings.

Secondly, not all packages of adequacies are correlated with statistically significant improvements in children's nutritional status. In other words, not *any* combination of adequate access to those services will lead to significant improvements in child nutrition. In fact, significant sets of integrated interventions vary across types of households (poor versus non-poor, rural versus urban, and across their combinations) and for some households, such as urban - especially non-poor urban, poor rural and wealthier households, few combinations of these integrated interventions appear to lead to significant improvements in reducing child stunting. This is either because of the already very low levels of stunting among children in urban areas and among wealthier households, which make additional improvements towards eradication harder to achieve, or because of the very low levels of adequacy among rural poor households that make marginal improvements insufficient to significantly improve stunting.

Importantly, adequate water and sanitation combined with other adequacies bring more frequently statistical significant effects on child nutrition (upper panel, Table 3). This is the case for adequate WASH combined with each of the food, care and health dimensions; and jointly with food, care and health access in the full sample (Table 3, column 1). But this is not always the case and in some contexts, this significant effect of WASH related synergies is not observed. For example, in urban areas, only adequate WASH and food access are correlated with significant child HAZ score improvements. Among non-poor rural households, only adequate WASH and care access; WASH and health care; and WASH care and health care have significant positive effects. In any case, the vast majority of coefficients reported for WASH have a positive sign, even though they are not significant. This indicates that WASH and other interaction effects may still be positively correlated with improved nutrition even though the magnitude of such effects is not sufficiently large to lead to significant effects.

Adequacies other than WASH (lower panel, Table 3) show somewhat different results; they are less likely to bring positive and significant effects into improved child nutrition. Also, some of the statistically significant effects are negative. This is mainly the case with care. This result does not necessarily mean that adequate care causes a deterioration in nutritional status but that households receiving psychosocial care or practicing prolonged breastfeeding are most vulnerable to stunting. Both results, a lower propensity to report significant synergies among dimensions other than WASH and some negative effects from care, are true for all considered sub-samples defined by households' socioeconomic status, their location or a combination of both (see Table 1, columns 2–11).

We also estimate alternative specifications, using different definitions of adequate water and sanitation services, i.e. using all improved water vis-à-vis only piped water, or all improved sanitation vis-à-vis sewerage or septic tank sanitation. Definitions also vary when taking into account whether or not child faeces are disposed of safely. Results do not change, but precision is affected given that fewer households report adequate access, especially in rural areas. When using a stricter definition of WASH adequacy, which includes safe removal of child faeces and improved water and sanitation, adequate access still brings significant and positive correlations with improved child nutrition (see Appendix 1, page 23). The achievement of this adequacy of WASH however, becomes more challenging when, for example, when we use definition 2 of adequacy (Table 1): all improved water, all improved sanitation, no shared toilets, and safe disposal of child faeces. In this case, only synergies involving environmental health become significant, largely reflecting the salience of community effects associated with faecal management.

Table 3 - *Effects of Food, Health, WASH, and Care Adequacies on Child Nutrition in Tunisia, 2011–12 (using adequacy definition 1)*

Model Adequacies	(1) full	(2) urban	(3) rural	(4) Non poor	(5) Poor	(6) Non poor urban	(7) Poor urban	(8) Non poor rural	(9) Poor rural	(10) quartile 2	(11) quartile 3	(12) quartile 4
WASH only	0.453***	0.518*	-0.022	0.468**	0.134	-0.068	1.549***	0.407	-0.247	-0.044	1.217***	-0.581
	[0.165]	[0.276]	[0.218]	[0.228]	[0.237]	[0.324]	[0.546]	[0.369]	[0.261]	[0.290]	[0.438]	[1.086]
WASH and Care only	0.759**	0.552	0.819**	0.672*	0.744*	-0.090		1.403**	0.558	0.379	0.957	0.198
	[0.296]	[0.479]	[0.372]	[0.397]	[0.429]	[0.503]		[0.683]	[0.426]	[0.572]	[0.727]	[1.241]
WASH and Food only	1.638***	1.319***	2.338	1.358***		0.677		2.410		1.530***	0.864	3.460**
	[0.327]	[0.393]	[1.631]	[0.358]		[0.424]		[1.672]		[0.469]	[0.621]	[1.441]
WASH and Health only	0.737***	0.345	1.086***	0.548***	0.472**	-0.265	1.286***	1.553***	0.291	0.577**	0.723*	-0.131
	[0.139]	[0.252]	[0.171]	[0.199]	[0.202]	[0.300]	[0.469]	[0.266]	[0.222]	[0.231]	[0.396]	[1.065]
WASH and Care and Food only	0.152	1.175	0.079	-0.080	0.208	0.778	2.098	0.220	-0.311	-0.310	1.597	
	[0.319]	[0.843]	[0.340]	[0.379]	[0.654]	[1.030]	[1.422]	[0.420]	[0.729]	[0.380]	[1.181]	
WASH and Care and Health only	0.170	-0.282	0.603**	-0.068	0.210	-0.848**	-0.432	0.782**	0.384	0.352	-0.442	-0.764
	[0.181]	[0.289]	[0.258]	[0.236]	[0.340]	[0.333]	[0.811]	[0.366]	[0.369]	[0.301]	[0.495]	[1.080]
WASH and Food and Health only	0.525***	0.355	0.251	0.190	1.053***	-0.399	2.662***	0.362	0.134	0.740	0.152	-0.461
	[0.193]	[0.295]	[0.315]	[0.248]	[0.366]	[0.341]	[0.649]	[0.429]	[0.475]	[0.455]	[0.509]	[1.079]
WASH and Care and Food and Health only	0.983***	1.131***	0.525	0.665**	1.361***	0.200	4.028***	0.809*	0.102	1.504***	0.805	-1.486
	[0.244]	[0.369]	[0.339]	[0.307]	[0.427]	[0.419]	[0.800]	[0.459]	[0.514]	[0.443]	[0.537]	[1.185]
Food only	0.165		0.293		0.430				0.244			
	[0.521]		[0.514]		[0.509]				[0.503]			
Health only	0.547***	0.527*	0.562***	0.762***	0.401*	0.113	1.149**	1.231***	0.226	1.003***	0.597	-0.707
	[0.165]	[0.306]	[0.191]	[0.241]	[0.215]	[0.359]	[0.571]	[0.318]	[0.230]	[0.274]	[0.484]	[1.153]
Care only	-1.140***		-1.012***	0.439	-0.947**			0.920	-1.132***	0.390		
	[0.375]		[0.375]	[1.844]	[0.383]			[1.818]	[0.382]	[1.679]		
Care and Food only	1.460*		1.588*		1.725**				1.539*			
	[0.854]		[0.836]		[0.819]				[0.803]			
Care and Health only	-0.544**	0.069	-0.481**	-0.720*	-0.313	0.405	0.507	-0.519	-0.498*	-0.068	-2.001***	0.820
	[0.223]	[0.739]	[0.238]	[0.413]	[0.263]	[1.026]	[1.057]	[0.460]	[0.272]	[0.500]	[0.768]	[1.608]
Food and Health only	1.147**		1.275***		1.412***				1.226***			
	[0.477]		[0.473]		[0.469]				[0.465]			
Care and Food and Health only	0.752	-0.981	1.278**	-0.814	1.473***	-1.622		0.380	1.288**		-0.656	
	[0.482]	[1.033]	[0.533]	[0.934]	[0.542]	[1.037]		[2.188]	[0.535]		[1.095]	
Constant	-0.590***	-0.289	-0.718***	-0.309	-0.855***	0.352	-1.678***	-0.790***	-0.669***	-0.260	-0.467	0.310
	[0.134]	[0.247]	[0.156]	[0.194]	[0.177]	[0.296]	[0.433]	[0.250]	[0.191]	[0.217]	[0.388]	[1.064]
Observations	3,516	1,887	1,629	2,339	1,177	1,679	208	660	969	802	803	734
R-squared	0.037	0.023	0.085	0.024	0.049	0.022	0.173	0.115	0.050	0.054	0.054	0.049

Source: Authors' estimates based on the 2011–12 MICS. – *Note:* Using WASH adequacy definition 1: All improved water, all improved sanitation, no shared toilet use, no child faeces considered. ***,**, and * refer to statistical significance levels of 1, 5, and 10 per cent, respectively, on a test of means. Standard errors in brackets.

We further explore the effects that a potential omitted variable bias may have. To the extent that variables not included in the current specifications - such as individual, household and community characteristics -affect both the dependent and independent variables, the estimated coefficients may be biased upwards or downwards (Greene, 2012). For example, a disadvantaged single mother may live in a neighbourhood with weak access to services and also be unable to invest sufficiently in the nutrition of her young children. In order to explore these effects, we re-estimate the synergies across adequacies for the full sample including a series of controls for individual, household and community levels. These controls include the age and gender of the child, birth order and whether the child was born in a multiple birth; the household size and composition, mother's and head's education, gender of the household head, mother's age and marital status, and wealth of the household; geographical location of the household and a proxy for the supply of services available at the community. It is worth noting that our original strategy of estimating synergies across subsamples of wealth and location of the household (Table 1, columns 2-12) already controls to large extent for such potential omitted variable bias (as household socio-economics, wealth and location are correlated to a considerable degree). Estimates for the conditioned specification on the full sample for adequacy definition 1 (Table 4, pages 19 and 20) suggest that the synergies found statistically significant in the unconditioned model remain so after introducing controls. Comparing the full unconditioned sample with the full conditioned model with all controls (Table 4, column 4) confirms that all WASH synergies remain significant except for WASH and care and WASH and food adequacies. For those WASH synergies that remain statistically significant across specifications, their estimated coefficients in the unconditioned model are smaller than in the conditioned specification, in an order of magnitude between 4 and 64 per cent.

These results have two important implications. First, the characteristics of the child expectedly have significant consequences on her nutrition status, and so does her mother's education and marital status. Gender of the household and number of young children in the household also affect a child's nutrition status, as well as the exposure of the household to shocks, and geographical location. Once controlled for these factors, head's education, household wealth, household size and the proxy for the health care service do not have a statistical significant effect. These results are robust to different specifications of controls (see columns 2 to 4 in table 4). Secondly, the additional controls used in these estimates correlate with the key drivers of nutrition defined by the UNICEF's framework, thus influencing synergies estimates. In fact, the omission of those controls biases downward the magnitude of the synergies estimated in the unconditioned model but does not typically change their significance nor sign.

Table 4 *– Effects of Food, Health, WASH, and Care Adequacies on Child Nutrition in Tunisia, 2011–12 on Conditioned Full Sample (using adequacy definition 1)*

Adequacies, Controls	Unconditioned	Conditioned (1)	Conditioned (2)	Conditioned (3)	Conditioned (4)
WASH only	0.453***	0.803***	0.677***	0.597***	0.649***
	[0.165]	[0.199]	[0.198]	[0.200]	[0.201]
WASH and Care only	0.759**	0.748**	0.651**	0.473	0.497
	[0.296]	[0.305]	[0.302]	[0.308]	[0.308]
WASH and Food only	1.638***	0.337	0.044	0.011	0.172
	[0.327]	[0.459]	[0.455]	[0.471]	[0.473]
WASH and Health only	0.737***	0.895***	0.756***	0.709***	0.765***
	[0.139]	[0.174]	[0.175]	[0.178]	[0.179]
WASH and Care and Food only	0.152	0.267	0.375	0.071	0.052
	[0.319]	[0.329]	[0.330]	[0.352]	[0.351]
WASH and Care and Health only	0.170	0.518**	0.447**	0.416*	0.449**
	[0.181]	[0.213]	[0.210]	[0.214]	[0.214]
WASH and Food and Health only	0.525***	0.884***	0.750***	0.823***	0.861***
	[0.193]	[0.236]	[0.234]	[0.241]	[0.242]
WASH and Care and Food and Health only	0.983***	1.737***	1.540***	1.536***	1.596***
	[0.244]	[0.298]	[0.296]	[0.299]	[0.300]
Food only	0.165	0.824	0.809	1.035	1.015
	[0.521]	[0.985]	[0.967]	[0.961]	[0.960]
Health only	0.547***	0.639***	0.591***	0.645***	0.644***
	[0.165]	[0.199]	[0.195]	[0.196]	[0.196]
Care only	-1.140***	-1.336***	-1.289***	-1.207***	-1.244***
	[0.375]	[0.446]	[0.438]	[0.437]	[0.437]
Care and Food only	1.460*	-	-	-	-
	[0.854]				
Care and Health only	-0.544**	-0.377	-0.388	-0.274	-0.325
	[0.223]	[0.251]	[0.247]	[0.247]	[0.247]
Food and Health only	1.147**	2.957***	3.169***	3.250***	3.264***
	[0.477]	[0.662]	[0.654]	[0.654]	[0.653]
Care and Food and Health only	0.752	1.833***	1.851***	1.950***	1.978***
	[0.482]	[0.506]	[0.496]	[0.495]	[0.494]
Log child's age		0.089*	0.044	0.033	0.026
		[0.046]	[0.045]	[0.046]	[0.046]
Female child		0.463***	0.518***	0.477***	0.475***
		[0.071]	[0.071]	[0.071]	[0.071]
Multiple birth		1.001***	1.229***	1.192***	1.211***
		[0.105]	[0.107]	[0.107]	[0.107]
Birth order		-0.222***	-0.208***	-0.162**	-0.139**
		[0.052]	[0.053]	[0.067]	[0.067]
Age of the mother			0.006	-0.001	-0.000
			[0.007]	[0.008]	[0.008]
Mother's education: none			-0.681***	-0.647***	-0.643***
			[0.147]	[0.191]	[0.191]

→ continues on page 20

Table 4 continues from page 19

Adequacies, Controls	Unconditioned	Conditioned (1)	Conditioned (2)	Conditioned (3)	Conditioned (4)
Mother's education: primary			-0.370***	-0.458***	-0.441***
			[0.122]	[0.160]	[0.161]
Mother's education: secondary			-0.316***	-0.413***	-0.406***
			[0.122]	[0.142]	[0.142]
Marital status: married			2.993***	3.264***	3.290***
		[0.374]	[0.378]	[0.377]	
Number of children aged 0-2 years				-0.228***	-0.234***
			[0.064]	[0.064]	
Number of children aged 2-14 years				-0.028	-0.041
			[0.060]	[0.060]	
Household size				0.010	0.003
			[0.027]	[0.027]	
Gender of the household head				1.022***	1.072***
			[0.197]	[0.198]	
Head's education: none				-0.135	-0.175
			[0.196]	[0.197]	
Head's education: primary				0.161	0.136
			[0.156]	[0.156]	
Head's education: secondary				0.216	0.210
			[0.143]	[0.143]	
Affected by shocks				-0.120*	-0.129
			[0.073]	[0.078]	
Wealth score				0.039	0.077
			[0.045]	[0.047]	
Acceded to clinic when household member ill					0.130
				[0.116]	
Urban					-0.247***
				[0.088]	
Constant	-0.590***	-1.084***	-3.768***	-3.605***	-3.586***
	[0.134]	[0.214]	[0.512]	[0.573]	[0.575]
Observations	3,516	2,240	2,240	2,239	2,239
R-squared	0.037	0.117	0.152	0.170	0.174

Source: Authors' estimates based on the 2011–12 MICS.
Note: Using WASH adequacy definition 1: All improved water, all improved sanitation, no shared toilet use, no child faeces considered. Using WASH adequacy definition 2: All improved water, all improved sanitation, no shared toilet use, and child faeces disposed of safely. Categories of reference: mother's tertiary education; head's tertiary education; marital status, never married. ***,**, and * refer to statistical significance levels of 1, 5, and 10 per cent, respectively, on a test of means. Standard errors in brackets.

5. CONCLUSIONS

Our analysis provides three contributions to the existing literature on nutrition. First, it develops an econometric strategy to *operationalize* UNICEF's Conceptual Framework of Child Nutrition. Second, it expands this conceptual framework to include synergies (i.e. effects that are beyond individual impacts) on nutrition from WASH interventions. Third, it estimates for the first time through a concrete case study of Tunisia - the effects that additional investment in WASH intervention packages have across different population groups (poor and non-poor) and residence (urban and rural). By so doing, the analysis does not settle for plain access/use variables, but constructs more data-demanding but at the same time, policy-relevant adequacy indicators. Our findings provide relevant policy insights on both the direct and indirect effects of WASH on child nutrition, as well as on how to increase nutrition impacts in WASH operations.

Notwithstanding data and methodological caveats, we conclude that adequate access to basic services matters in achieving improved child nutrition in Tunisia, a country whose progress in reducing stunting is notable, but rather uneven. WASH has a statistically significant positive link with improved child nutrition: more and better access to improved water and sanitation and non-shared toilets are likely to have significant beneficial effects on child nutrition. In fact, multiple adequacies with WASH present are the most likely to have a significant impact on nutrition compared to adequate access to food, health, and care. Critically however, estimated effects differ across samples of poor, non-poor, urban and rural, and across quartiles of households (not shown in our tables).

For policy purposes, two key messages stand out for Tunisia. Progress toward satisfying a very strict level of adequacy in WASH – or any single dimension of public service – will not bring considerable gains in child nutrition unless similar gains in other services are also attained. Neither will a single intervention package (for example, WASH improvement combined with another single basic service intervention) bring uniform benefits across different types of households (poor/non-poor, urban/rural, most/least vulnerable groups). Since the effects of improved access vary by group and by area, and given that investments are limited, interventions would need to selectively respond to the specific requirements of different types of household, location, and vulnerability, before they improve nutrition evenly for Tunisian children.

While these messages are hardly surprising, their quantification is not so straight-forward. In practice, the proposed analytical approach allows us to identify differences across population groups and regions, estimate their magnitudes, and suggest priority areas of intervention on child undernourishment.

Although the methodological extension is only applied to Tunisia, it lends itself to replication in multiple countries, even in relatively data-poor contexts. At the time of writing, efforts are underway to replicate this approach in countries including Bangladesh, Bolivia, Cambodia, Ethiopia, Indonesia, Nepal, Peru and Zimbabwe (Skoufias, 2016). To the extent that countries have repeated socio-economic household surveys, panel surveys and dedicated surveys that collect information on quality issues, the precision of estimated results are expected to improve.

Another direction of analysis refer to regional differences within countries. In Tunisia, marked developmental gaps exist between the western and eastern regions, and also across samples of countries – for instance, North Africa, the Middle East, and West Africa.

Several caveats are worth mentioning. These findings draw from correlations rather than unambiguous causal effects. More effort is therefore needed to disentangle endogenous relationships. After all, investments are expected to be (and even designed to target) those who are most in need, i.e. groups and areas most lagging behind in adequate access. Future analysis will need to consider synergies between other potential drivers of nutrition (not included here because they are not captured by the MICS) such as public awareness campaigns, improved education among future parents and safety nets. The analysis of adequate services needs validation across other health dimensions, such as weight-for-age or the incidence of child diarrhoea (which could not be analysed in the case of Tunisia due to data constraints) and across different age groups (for instance within childhood and between children and adolescents). It is also worth noting that height-for-age is a latent stock variable for health, that is, a long-term proxy for physical development (Case and Paxson, 2008). As such, it is less likely to be subject to dramatic short-term variations. This implies that only the effects from the most impactful synergies are likely to be captured. Finally, to make these results fully operational, further knowledge is still needed on programming aspects, such as the effectiveness of scaling up interventions or the introduction of results-based financing mechanisms.

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Appendix 1 – ***Effects of Food, Health, WASH and Care Adequacies on Child Nutrition in Tunisia, 2011-12 by Wealth and Location Samples (using adequacy definition 2)***

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Adequacies	full	urban	rural	Non poor	Poor	Non poor urban	Poor urban	Non poor rural	Poor rural	quartile 2	quartile 3	quartile 4
WASH only	-1.240**	-1.300	-0.957	0.281	-0.920*	0.015	-0.996		-0.899	0.599		
	[0.534]	[0.967]	[0.631]	[1.937]	[0.531]	[1.919]	[1.144]		[0.599]	[1.763]		
WASH and Health only	0.752***	-0.073	1.800***	0.108	1.896***	-0.178	0.154	0.838	2.185***	-0.311	-0.269	
	[0.263]	[0.345]	[0.402]	[0.327]	[0.422]	[0.359]	[1.199]	[0.768]	[0.447]	[0.913]	[0.411]	
WASH and Care and Health only	0.956*	0.268	1.699**	0.663		0.115		1.603**				0.939*
	[0.557]	[0.775]	[0.791]	[0.564]		[0.770]		[0.812]				[0.552]
WASH and Food and Health only	0.603		1.038		1.071				1.096			
	[1.220]		[1.199]		[1.152]				[1.130]			
WASH and Care and Food and Health	-1.596	-2.002		-1.889		-2.155*						-1.613
	[1.233]	[1.242]		[1.242]		[1.232]						[1.154]
Food only	0.929***	0.887***	0.444	1.019***	0.307	0.734**		2.223	0.332	1.559***	-0.090	4.017***
	[0.270]	[0.326]	[0.488]	[0.318]	[0.491]	[0.327]		[1.669]	[0.484]	[0.440]	[0.521]	[0.994]
Health only	0.377***	-0.075	0.894***	0.229**	0.266*	-0.188	0.227	1.317***	0.274*	0.689***	-0.239	0.416*
	[0.088]	[0.120]	[0.128]	[0.110]	[0.143]	[0.129]	[0.322]	[0.202]	[0.159]	[0.162]	[0.199]	[0.223]
Care only	-0.252	0.120	-0.105	0.326	-0.343	-0.033		1.162*	-0.319	0.409	0.003	0.755
	[0.226]	[0.425]	[0.268]	[0.356]	[0.282]	[0.424]		[0.629]	[0.283]	[0.525]	[0.645]	[0.674]
Care and Food only	-0.036	0.743	0.241	-0.418	0.666	0.835	1.064	0.033	0.607	-0.281	0.644	
	[0.286]	[0.814]	[0.309]	[0.341]	[0.508]	[0.994]	[1.405]	[0.386]	[0.540]	[0.345]	[1.138]	
Care and Health only	-0.429***	-0.735***	-0.086	-0.546***	-0.273	-0.798***	-1.151*	0.052	-0.169	0.306	-1.671***	-0.340
	[0.130]	[0.186]	[0.179]	[0.165]	[0.201]	[0.195]	[0.632]	[0.295]	[0.213]	[0.239]	[0.334]	[0.294]
Food and Health only	0.248	-0.077	0.491*	-0.148	1.056***	-0.342	1.628***	0.174	0.757**	0.768*	-0.802**	0.096
	[0.156]	[0.196]	[0.266]	[0.185]	[0.290]	[0.208]	[0.564]	[0.395]	[0.343]	[0.426]	[0.378]	[0.282]
Care and Food and Health only	0.672***	0.675**	0.701**	0.309	1.280***	0.237	2.994***	0.609	0.756**	1.532***	-0.319	-0.747
	[0.206]	[0.292]	[0.286]	[0.255]	[0.331]	[0.316]	[0.737]	[0.422]	[0.370]	[0.413]	[0.396]	[0.624]
Constant	-0.264***	0.142	-0.699***	0.029	-0.732***	0.295**	-0.644**	-0.603***	-0.757***	-0.289**	0.486***	-0.247
	[0.080]	[0.111]	[0.112]	[0.102]	[0.121]	[0.120]	[0.276]	[0.185]	[0.134]	[0.145]	[0.182]	[0.215]
Observations	3,516	1,887	1,629	2,339	1,177	1,679	208	660	969	802	803	734
R-squared	0.028	0.022	0.061	0.023	0.051	0.020	0.139	0.105	0.044	0.049	0.037	0.052

Source: authors' estimates based on MICS 2011–12.

Note: Using WASH adequacy definition 1: All improved water, all improved sanitation, no shared toilet use, no child faeces considered. Using WASH adequacy definition 2: All improved water, all improved sanitation, no shared toilet use, and child faeces disposed of safely. ***,**, and * refer to statistical significance levels of 1, 5, and 10 per cent, respectively, on a test of means. Standard errors in brackets.