

Concurrent wasting and stunting among under-five children in Niakhar, Senegal

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Abstract

The study describes the patterns of concurrent wasting and stunting (WaSt) among children age 6–59 months living in the 1980s in Niakhar, a rural area of Senegal under demographic surveillance. Wasting and stunting were defined by z scores lower than –2 in weight for height and height for age. Both conditions were found to be highly prevalent, wasting more so before age 30 months, stunting more so after age 30 months. As a result, concurrent WaSt peaked around age 18 months and its prevalence (6.2%) was primarily the product of the two conditions, with an interaction term of 1.57 ($p < 10^{-6}$). The interaction was due to the correlation between both conditions (more stunting if wasted, more wasting if stunted). Before age 30 months, boys were more likely to be concurrently wasted and stunted than girls (RR = 1.61), but the sex difference disappeared after 30 months of age. The excess susceptibility of younger boys could not be explained by muscle mass or fat mass measured by arm or muscle circumference, triceps, or subscapular skinfold. Concurrent WaSt was a strong risk factor for child mortality, and its effect was the product of the independent effect of each component, with no significant interaction.

KEYWORDS

anthropometry, child survival, concurrent wasting & stunting, Senegal, stunting, wasting

1 | INTRODUCTION

Malnutrition in children under five is still widely prevalent in the world. It is the focus of numerous research works and of numerous public health interventions (Black et al., 2008; Briend, Collins, Golden, Manary, & Myatt, 2013; McDonald et al., 2013). Child malnutrition is primarily defined by anthropometric indicators, in reference to international growth standards elaborated in populations free of malnutrition. These anthropometric indicators describe the various

dimensions of child growth in particular linear growth (bones), fat, and muscle. The aetiology of malnutrition is complex, as nutritional status is the product of numerous interactions between food intake, disease, metabolism, immunity, and endocrine system. Of particular importance for lower-and-middle-income countries (LMIC) is the well-documented synergistic effect of nutrition and infection (Scrimshaw, 2003; Scrimshaw & SanGiovanni, 1997). A recent review summarized current knowledge on the complex interactions between nutritional status (linear growth, fat, muscle) and body

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functions (metabolism, immunity, endocrine system; Briend, Khara, & Dolan, 2015). Of particular importance is the role of muscle on the production of amino acids necessary for vital organs (heart, kidney, thymus) and that of fat as an energy provider. Fat also has an influence on hormonal production, in particular leptin, which has numerous effects on the immune system as well as on linear growth. Various forms of malnutrition may result from deficits in diet (low food intake, deficits in micronutrients and vitamins, imbalance between proteins, carbohydrates, and lipids), from infections, or from dysfunctions of organs. In turn, these anomalies may have an impact on child growth measured by anthropometric indicators.

In nutritional epidemiologic studies, nutritional status is first defined by weight and height in relation to age. In the early 1970s, John Waterlow introduced a distinction between wasting (acute malnutrition) defined by low weight for height and stunting (chronic malnutrition) defined by low height for age. Both indicators were assumed to be largely independent of each other (Waterlow, 1972). The proportion of children who are wasted and the proportion of children who are stunted are the leading indicators of nutritional status used in Demographic and Health Surveys, conducted throughout LMIC (Akombi, Agho, Merom, Renzaho, & Hall, 2017). Wasting is more typical in younger children (6–29 months) and stunting in older children (30–59 months), although both could occur at any age. Children under 6 months of age, most of them fully breastfed, have been assumed to be relatively free of malnutrition, although this assumption has been challenged in the literature (Kerac, Mwangome, McGrath, Haider, & Berkley, 2015). In most countries, and in particular in sub-Saharan Africa, sex differences in prevalence of malnutrition are small, if not negligible (Garenne, 2003). Large sex differences in nutritional status and mortality are found mostly in South-Asia and are associated with family composition and differential food allocation by sex and birth order, with girls of birth order 2+ being at higher risk (Das Gupta, 1987; Mishra, Roy, & Retherford, 2004; Pande, 2003). No such effects have been documented so far in Africa (Garenne, 2003).

Recent research has revisited the relationships between wasting and stunting, partly because it is now recognized that many common factors could cause both conditions, that their effect on mortality is due to the same mechanisms, with similar changes in body composition and partly because prevention strategies are similar for both conditions (Briend et al., 2015; Victora, 1992; Martorell & Young, 2012). In addition, there is a renewed interest in concurrent WaSt (defined as being both wasted and stunted at the same time), a condition that has been rarely studied. This more severe pathology may necessitate special treatments or special attention because of its high mortality risk (McDonald et al., 2013). In recent studies, concurrent WaSt was found more prevalent than assumed earlier and is now seen as a specific problem requiring special attention (Angood, Khara, Dolan, & Berkley, 2016; Bergeron & Castleman, 2012; Khara & Dolan, 2014; Khara, Mwangome, Ngari, & Dolan, 2018; Myatt et al., 2017; Myatt et al., 2018; Richard et al., 2012).

The aim of this paper is to describe the demographic patterns (prevalence, age pattern, sex differences, mortality) of concurrent WaSt, in a rural community of Senegal, using data collected in the 1980s.

Key messages

- Prevalence of concurrent wasting and stunting (WaSt) among under-five children is the product of independent wasting and stunting, plus an interaction term of 57%.
- Prevalence of WaSt peaks around age 18 months.
- Prevalence of WaSt is about 50% higher among boys than among girls before age 30 months, largely because their higher susceptibility to stunting but not higher thereafter.
- Excess mortality associated with WaSt is the product of that associated with wasting and that associated with stunting.

2 | DATA AND METHODS

The data used for this analysis were collected in the early 1980s as part of a comprehensive research project on the relationships between nutritional status and mortality among preschool children. This dataset is large and comprehensive and has been used for comparative studies. The project has been described in details elsewhere (Briend, Garenne, Maire, Fontaine, & Dieng, 1989; Briend, Maire, Fontaine, & Garenne, 2012; Garenne et al., 2009; Garenne, Maire, Fontaine, & Briend, 2006, 2012; Garenne, Maire, Fontaine, Dieng, & Briend, 1987, 2000). In brief, the study was conducted in a rural community of about 25,000 people living in 30 villages near Niakhar, Fatick region, in central Senegal. This population was living on farming, growing millet and peanuts, and raising cattle, sheep, and goats. Living standards were still low at that time, prevalence of malnutrition moderate, and under-five mortality was very high (271 per 1,000 live births).

The Niakhar study was conducted in the framework of a comprehensive Demographic Surveillance System, with full counts of population dynamics (births, deaths, immigration and outmigration). All under-five children living in the study area were visited four times at 6-month interval (May and November 1983 and 1984), with comprehensive anthropometric assessment (weight, height, head circumference, arm circumference, triceps skinfold, subscapular skinfold). For this study, children age 6–59 months were selected, who had complete measures at nutritional assessment ($N = 12,638$ in total). Children could be seen one, two, three or four times depending on their age and availability: 2,708 children in May 1983, 3,253 children in November 1983, 3,380 children in May 1984, 3,297 children in November 1984, for an average of 3,160 children per visit. The unit of analysis was the visit, a combination of child and age. All children were monitored for survival for 6 months after each nutritional assessment (304 deaths were recorded). More details on the study can be found elsewhere (Garenne et al., 1987, 2000, 2006, 2009, 2012). Anthropometric measures were standardized (z scores) using the CDC-2000 growth standards: weight-for-age (WAZ), height-for-age (HAZ), and weight-for-height (WHZ) (CDC, 2000). The use of CDC-2000 standard was justified here because it provided the highest sensitivity and specificity for screening the mortality risk.

2.1 | Case definitions

This study focuses on wasting, stunting, and concurrent WaSt, defined as follows:

Stunted: HAZ < -2.0.

Wasted: WHZ < -2.0.

Concurrently wasted and stunted (WaSt): WHZ < -2.0 and HAZ < -2.0.

Severity of concurrent WaSt: "mild" = WHZ < -1.0 and HAZ < -1.0; "moderate" = WHZ < -2.0 and HAZ < -2.0; "severe" = WHZ < -3.0 and HAZ < -3.0 (categories are exclusive of each other, with highest severity prevailing).

For multivariate analysis, two other indicators were calculated:

Combined WaSt z score: $WaStZ = (WHZ + HAZ)/2$ if WHZ < 0 and HAZ < 0; = 0 otherwise.

Interaction between wasting z score and stunting z score: $WaxStZ = -(WHZ \times HAZ)$ if WHZ < 0 and HAZ < 0; = 0 otherwise.

2.2 | Methods

Straightforward statistical methods were used for this study: basic cross-tabulations and multivariate analysis, using linear models (on z scores) and Logit-linear models (on prevalence of conditions). All calculations were done using SPSS-17.

3 | RESULTS

3.1 | Prevalence of wasting, stunting, and interaction

The prevalence of wasting (16.3%), stunting (24.2%), and concurrent WaSt (6.2%) was moderate in Niakhar, with higher wasting and lower stunting than the national average for Senegal in 1992 and than the average of African countries in the 1990s (6.8% wasting and 36.4% stunting). Considered by 12-month age groups, wasting was highest at 12–23 months, stunting at 24–35 months, and concurrent WaSt at 12–23 months. The prevalence of concurrent WaSt was 1.57 times the product of the prevalence of wasting by that of stunting, indicating an interaction between the two conditions (under the hypothesis of

independence it should be equal to the product). This interaction was highest for children age 6–11 months (2.16, $p = 0.038$) and lowest (1.21) for children age 48–59 months (Table 1).

The interactions between wasting and stunting are further illustrated in Figure 1: The proportion of wasted children increased markedly with the degree of stunting, in a dose-response (log linear) relationship. Similarly, the proportion of stunted children increased with the degree of wasting, although the relationship was less linear (Figure 1).

The interaction between wasting and stunting (defined by -2 z score) was further investigated by linear-logistic regression of the proportion wasted (dependent variable) on stunting (independent variable), after controlling for age and sex. The effect of stunting on wasting was strong and highly significant and similar for younger children age 6–29 months and for older children age 30–59 months. An increase in stunting of -2 units in z score increased the probability of being wasted 2.43 times below age 30 months and 2.11 times above 30 months. Surprisingly, male sex had a positive effect below age 30 months (+12% more wasting among boys at the same level of stunting) but negative above age 30 months (-20% less wasting among boys at the same level of stunting) (Table 2).

3.2 | Age patterns

The age patterns of wasting, stunting, and interaction are displayed in Figure 2. After the age of 6 months, the proportion of wasted children increased rapidly with age, peaked around 16 months (31%), and declined first slowly, then rapidly to reach low levels (7%) after 42 months. The proportion of stunted children increased less rapidly with age, reached a later peak around 28 months (33%), before declining slowly and remaining at high level (20%) by age 59 months. The proportion of children concurrently wasted and stunted followed the product wasted \times stunted, with a fast increase from 6 to 18 months, a peak around 19 months (12%), followed by a decline after 24 months and becoming negligible after 48 months (1.7%). Age is therefore a fundamental aspect of the dynamics of the patterns of malnutrition among these children.

3.3 | Sex differences

As already noticed (see Table 2), sex differences in susceptibility to concurrent WaSt were very marked, atypical, and changing with age.

TABLE 1 Prevalence of wasting, stunting, and concurrent wasting and stunting, by age group, Niakhar 1983–1984 (N = 12,638 measures)

Age group (months)	Prevalence (%)			Interaction	
	Wasted (WHZ < -2) (Wa)	Stunted (HAZ < -2) (st)	Wasted and stunted (wast)	Value (wast/Wa \times st)	95% CI Min-max
6–11	19.9%	10.6%	4.5%	2.16*	1.62–2.87
12–23	29.5%	26.0%	11.0%	1.44*	1.25–1.66
24–35	18.2%	32.4%	9.1%	1.54*	1.29–1.82
36–47	7.2%	26.3%	3.6%	1.91*	1.49–2.45
48–59	6.9%	20.7%	1.7%	1.21	0.86–1.69
Total	16.3%	24.2%	6.2%	1.57*	1.43–1.72

Note. Interaction terms were statistically significant (RR >> 1), with p values < 10^{-6} , except for the 48–59 age group (not significant). p values and confidence intervals calculated with standard formulae for risk ratios. (*) $p < 0.05$.

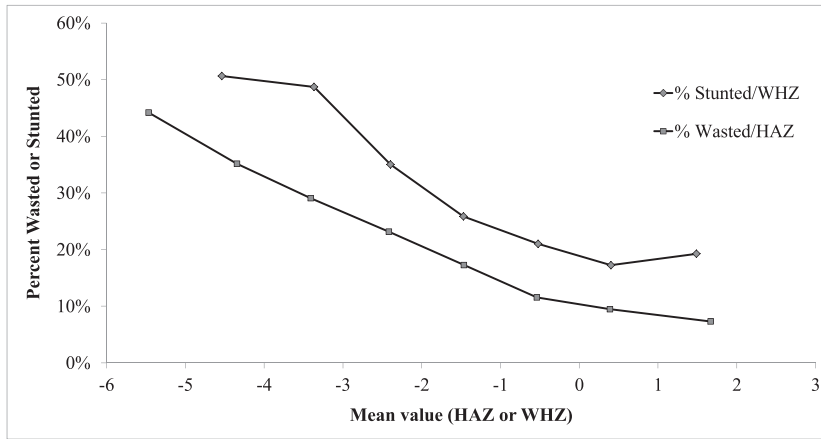


FIGURE 1 Interactions between wasting and stunting, Niakhar 1983–1984. (a) Effect of wasting on stunting, (b) Effect of stunting on wasting

TABLE 2 Net effect of stunting, age, and sex on wasting, Niakhar 1983–1984

Variable	Children 6–29 months		Children 30–59 months		Difference between age groups <i>p</i> value
	B coefficient	<i>p</i> value	B coefficient	<i>p</i> value	
HAZ	-0.4435	<10 ⁻⁶ *	-0.3725	<10 ⁻⁶ *	0.114
Sex (male)	+0.1170	0.057	-0.2240	0.015*	0.002*
Age	+0.2094	<10 ⁻⁶ *	-0.3559	<10 ⁻⁶ *	<10 ⁻⁶ *
Age ²	-0.0063	<10 ⁻⁶ *	+0.0039	<10 ⁻⁶ *	<10 ⁻⁶ *
Constant	-3.1984	<10 ⁻⁶ *	+5.0068	<10 ⁻⁶ *	<10 ⁻⁶ *

Note. Dependent variable = proportion wasted (WHZ < -2); (*) *p* < 0.05. The net effect of each variable can be computed as = exp (bX). Age and age² were used because the relationship with age was curvilinear. Sex = 1 for males, 0 for females.

The issue of sex differences was further investigated by calculating the sex ratios of prevalence, defined as the ratio of male prevalence/female prevalence. Wasting was more prevalent among young boys, (before age 24 months) and similar in older boys and girls. Stunting was always more prevalent among boys and more so before 36 months; interactions were roughly equivalent between boys and girls, with a small (not significant) trend towards being more pronounced for younger boys (age 6–23 months) and less pronounced for older boys (36–59 months) (Table 3).

Figure 3 displays the pattern of sex differences in concurrent WaSt into more details. Prevalence of WaSt was much higher for males at 6–23 months (RR = 1.77) and no difference after 24 months, with a minor tendency to higher prevalence among females. A multivariate analysis conducted after controlling for age showed that the net effect of sex on WaSt changed sign between age 6–29 months ($b = +0.534$, $p < 10^{-6}$) and age 30–59 months ($b = -0.095$, $p = 0.495$), the change being highly significant ($p < 10^{-6}$).

3.4 | Impact of severity of concurrent WaSt on sex differences

The severity of concurrent WaSt was calculated from the composite index defined above: (WHZ + HAZ)/2 if both negative, 0 otherwise. Severity categories were: “mild” for $Z < -1$, “moderate” for $Z < -2$, and “severe” for $Z < -3$. The pattern of sex differences was proportionate to the degree of severity of concurrent WaSt below age 30 months but not above age 30 months. (Figure 4).

3.5 | Relationships with other anthropometric indicators

Anthropometric indicators are good proxies for body composition, although fat mass and muscle mass measured by dual-energy X-ray absorptiometry can only be approximated by anthropometric

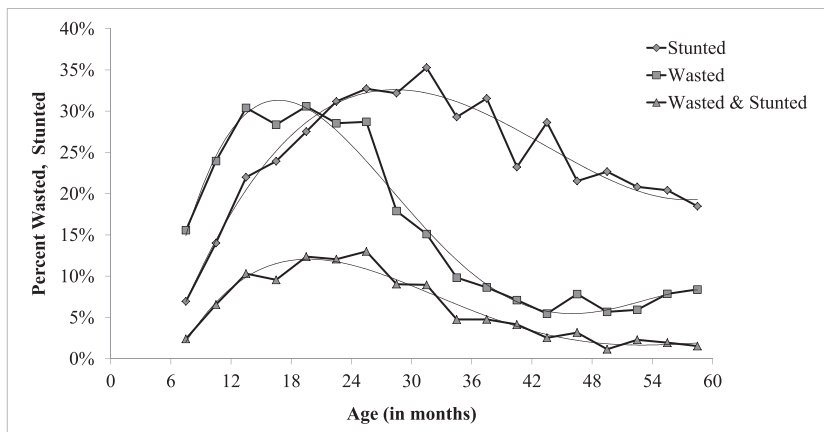


FIGURE 2 Prevalence by age of wasting, stunting, and concurrent wasting and stunting, Niakhar 1983–1984

TABLE 3 Sex ratios of prevalence of wasting, stunting, and concurrent wasting and stunting, by age group, Niakhar 1983–1984

Age group (months)	Sex ratio of prevalence (boys/girls)				Interaction Value (wast/Wa × st)
	Wasted (WHZ < -2) (Wa)	Stunted (HAZ < -2) (st)	Wasted and stunted		
			Sex ratio (wast)	p value (wast)	
6–12	1.23*	1.82*	2.34*	7.5E-04*	1.04
12–24	1.20*	1.35*	1.69*	5.3E-06*	1.04
24–36	1.01	1.24*	1.17	0.230	0.93
36–48	0.77	1.12	0.82	0.329	0.96
48–60	0.84	1.14	0.88	0.677	0.91
Total	1.08	1.24	1.36*	2.4E-05*	1.02

Note. (*) $p < 0.05$. p values test the sex ratio for wasting and stunting (SR < > 1). None of the sex ratio of the interactions was significant.

measures (Jensen et al., 2015). Body composition differs between sexes: Boys have a higher fat-free mass and a lower fat mass than girls. In Niakhar (as elsewhere), boys had a larger arm circumference (143.5 mm) than girls (142.7 mm), the difference being significant ($p = 0.014$), and this was true at all ages. This difference did not correlate with their higher susceptibility to concurrent WaSt at younger ages. When standardized by age, boys had a lower MUAC-for-age z score (-1.485) than girls (-1.324), the difference being highly significant ($p < 10^{-6}$). This difference was consistent at all ages, although the difference was more pronounced before age 30 months (-0.25 z score), than after age 30 months (-0.08 z score). This is the only difference that goes in the direction of observed differences in prevalence of concurrent WaSt between boys and girls. However, it does not seem to explain these observed differences. In fact, adding MUAC-for-age z score in a multivariate analysis reduced the net effect of sex for younger and older children but did not modify the relative risks between younger (1.88) and older children (1.68).

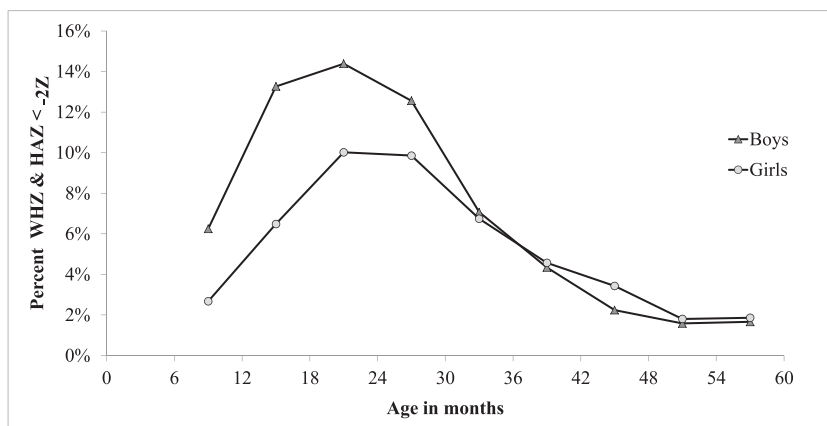
Overall, girls had thicker triceps skinfolds (8.57 mm) and thicker subscapular skinfolds (6.31 mm) than boys (8.15 mm and 5.98 mm respectively), the differences being highly significant ($p < 10^{-6}$). The difference in triceps and subscapular skinfolds between boys and girls was very small at age 6–11 months (-0.052 and -0.048 mm) and tended to

increase with age up to age 59 months (-0.522 and -0.564 mm). Therefore, this difference did not correlate with sex differences in concurrent WaSt, and in fact, it goes in the opposite direction: The increasing advantage of girls in fat stores is associated with their decreasing advantage compared with boys in the risk of being simultaneously wasted and stunted. Overall, boys had a larger muscle circumference (117.9 mm) than girls (116.8 mm), and the difference between both (2.1 mm) was consistent over age from 6 to 59 months. Muscle mass was therefore not associated with the changing sex difference in concurrent WaSt.

Prevalence of concurrent WaSt was further analysed in multivariate analysis with respect to anthropometric indicators other than weight and height: head circumference, triceps skinfold, subscapular skinfold, and muscle arm circumference, plus age and sex. In both age groups, the net effects of anthropometric indicators were all statistically significant, in the same direction (positive or negative) and of about the same magnitude. The net effect of sex was in the same direction but not of the same magnitude. The effect of age changed markedly (as seen earlier on Figure 2). The effect of muscle circumference increased with increasing age. The changing sex ratio was conserved, with higher values before age 30 months (SR = 4.24) than after (SR = 1.75), the difference being significant ($p < 10^{-4}$). In this case however, boys appeared to be always at higher risk of being concurrently wasted and stunted, after controlling for the other variables (Table 4).

3.6 | Mortality risk

Numerous studies have documented the relationships between nutritional status and under-five mortality (McDonald et al., 2013; Pelletier, 1994). An earlier analysis of the same data showed the independent effects of anthropometric indicators on child survival and in particular those of wasting and stunting (Garenne et al., 2006). The current analysis provides further evidence by age and sex. Wasting, stunting, and their interaction had a positive effect on mortality (lower z scores increased the risk of death), the effect being significant only for wasting at age 6–29 months and the effect being only significant for stunting at age 30–59 months. The interaction term added only little (1.08 and 1.15 respectively) and was not statistically significant in any of the two age groups. Sex differences in mortality were not significant after controlling for stunting and wasting (Table 5).

FIGURE 3 Sex differences in prevalence of concurrent wasting and stunting, Niakhar 1983–1984

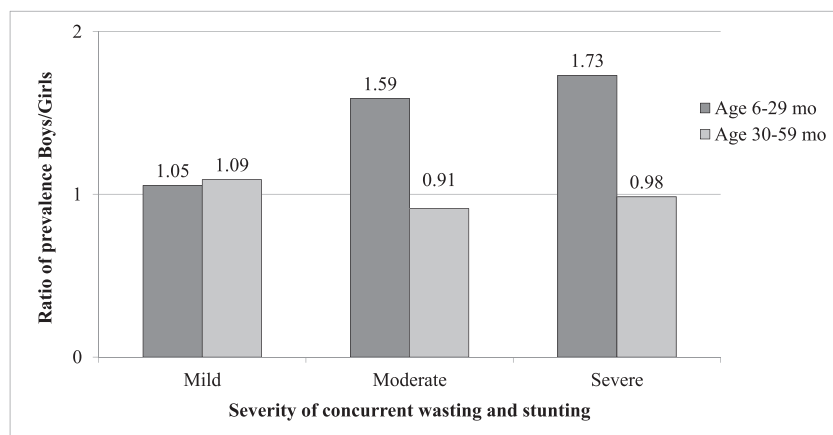


FIGURE 4 Effect of severity of concurrent wasting and stunting on sex differences in prevalence, Niakhar 1983–1984

TABLE 4 Effect of age, sex, and anthropometric indicators on prevalence of concurrent wasting and stunting, Niakhar 1983–1984

Variable	Children age 6–29		Children age 30–59		Difference in coefficients
	Coefficient	<i>p</i> value	Coefficient	<i>p</i> value	<i>p</i> value
Age	+0.716	<10 ^{-6*}	-0.036	0.746	<10 ^{-6*}
Age ²	-0.014	<10 ^{-6*}	+0.001	0.628	<10 ^{-6*}
Sex (male)	+1.446	<10 ^{-6*}	+0.562	0.0020*	<10 ^{-4*}
Head circumference	-0.055	<10 ^{-6*}	-0.053	<10 ^{-6*}	0.814
Tricipital	-0.038	<10 ^{-6*}	-0.041	<10 ^{-6*}	0.755
Subscapular	-0.018	0.0054*	-0.018	0.060	0.974
Muscle circumference	-0.160	<10 ^{-6*}	-0.193	<10 ^{-6*}	0.028
Constant	34.764	<10 ^{-6*}	47.961	<10 ^{-6*}	

Note. (*) *p* < 0.05. Dependent variable: prevalence of concurrent wasting and stunting (WHZ and HAZ < -2 z score). Head circumference and muscle arm circumference in mm. Triceps and subscapular skinfold in 10 × mm. Sex = 1 for males, 0 for females.

TABLE 5 Effect of age, sex, stunting, wasting, and interaction on mortality, Niakhar 1983–1984

Variable	Children age 6–29 months			Children age 30–59 months		
	B coefficient	<i>p</i> value	Net effect	B coefficient	<i>p</i> value	Net effect
Age	-0.0004	0.969		-0.0339	0.027*	
Sex	-0.0154	0.909		-0.3785	0.126	
Stunting	-0.1378	0.150	1.31	-0.4751	0.00007*	2.57
Wasting	-0.2608	0.004*	1.66	-0.0552	0.752	1.12
Interaction	-0.0412	0.326	1.08	-0.0714	0.288	1.15
Constant	-3.8629	<10 ^{-6*}		-3.9151	<10 ^{-6*}	

Note. Net effect = relative risk of mortality associated with -2 z score; sex = 1 for males; stunting and wasting defined by dummy variables; (*) *p* < 0.05.

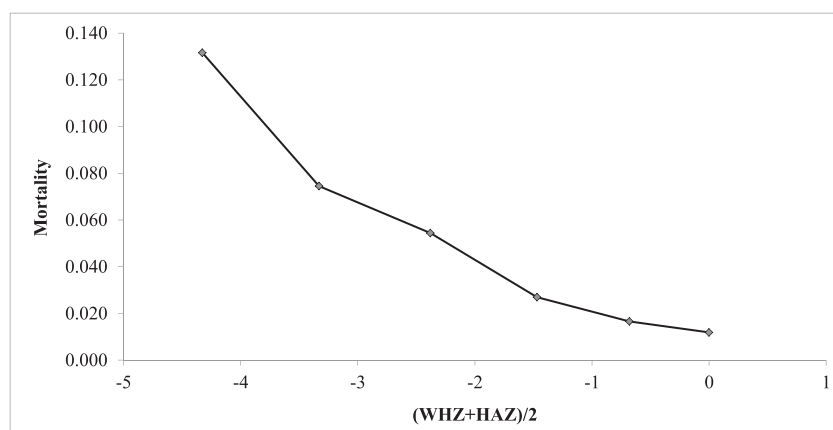


FIGURE 5 Mortality according to the combined effect of stunting and wasting, Niakhar 1983–1984

Altogether, the combined effect of wasting and stunting appears to have a huge effect on child survival: The mortality of children who are below -4 z score, computed as $(WHZ + HAZ)/2$, is 11.1 times that of children who are above the median in weight for height and height for age. In terms of attributable risk, the combined effect of WaSt explained some 51% of the total mortality (Figure 5). However, this effect remains still lower than that produced by MUAC (Garenne et al., 2006).

4 | DISCUSSION

This study explored the interactions between wasting and stunting. Overall, wasting and stunting appear at first glance as largely independent, as they do not pertain to the same age groups and as the prevalence of concurrent WaSt by age is primarily defined by the product of both conditions. However, the interaction term (57% excess prevalence compared with the product) was significant, indicating that stunting and wasting are correlated. This interaction has implications for early detection and treatments of children at highest risk due to the multiplicative effect of both conditions on child mortality (additive effects in the logarithm of mortality risk translate into multiplicative effects).

The interactions between wasting and stunting raise a new question: Are they both produced by a common factor (nutritional, immunological, hormonal) or by increased susceptibility (stunted children being more likely to become wasted and wasted children being more likely to become stunted). This point requires further investigation.

The prevalence of concurrent WaSt can be only partly explained by linear growth, muscle mass, and fat mass, as measured by available anthropometric indicators, all playing an independent and significant role. More research is needed on the precise role of muscle mass and fat mass with more precise measures than anthropometry. This study therefore suggests the existence of other underlying factors, which cause variations by age and sex. In particular, large differences by age suggest that other strong factors are playing a role: Immunological factors, as a result of the synergistic effect of repeated infections on the immune system or hormonal factors caused by the complex production of hormones in infancy and childhood and their interactions with metabolism.

One of the most striking findings of this study was the sex difference, which changes rapidly with age. Changing sex ratios with age suggests the action of sex-specific hormones. This has been found for a variety of infectious diseases, for auto-immune diseases, for asthma, and other conditions. (Garenne, 2015; Garenne & Lafon, 1998). Here, the situation shows a higher susceptibility for boys below age 30 months, which disappears thereafter. This could be due to one of the sex hormones increasing susceptibility of boys at an early age and becoming silent later (Bartz et al., 2014). A potential candidate is testosterone, which is produced in early infancy and tends to disappear later, to become revived at adolescence: Testosterone could have an effect on boy's stunting in infancy, with some long-term effects in the second year of childhood (Kuiri-Hänninen, Sankilampi, & Dunkel, 2014). Another candidate is the difference in the dynamics of Luteinizing hormone and Follicle-stimulating hormone (FSH) among boys and girls: In particular, FSH tends to disappear among boys after age 6 months, while it stays at high levels in girls until 3 to 4 years, which apparently matches the pattern found for concurrent WaSt (Kuiri-

Hänninen et al., 2014). Other potential candidates are Sertoli cell hormones (Müllerian inhibiting substance or the inhibin B), shown to have an effect on boys stature (Andersson et al., 1998; Morgan, Dennis, Ruffman, Bilkey, & McLennan, 2011). Further research is needed in this field to clarify these complex issues.

Whatever the aetiology of concurrent WaSt, the case deserves more attention because of its impact on child survival. Prevention, early detection, and appropriate treatments need to be identified to tackle this important public health issue, affecting millions of children in developing countries (Briend, 2015).

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

CONTRIBUTIONS

MG and AB initiated the study and conducted the field work. MG conducted the statistical analysis and wrote the first draft. All authors contributed to the paper through comments and references, and all agree with the final draft.

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