An Extra Grain of Salt: The Effect of Salinity Exposure on Early Life Health Outcomes in Coastal Bangladesh

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Rising ocean salinity levels pose a serious threat to public health and livelihoods in Bangladesh, a low-lying country vulnerable to climate change. In this paper, we present novel evidence for the effects of *in utero* exposure to high salinity levels on children's nutritional status as measured by standardized anthropometric measures. Leveraging six geo-referenced waves of the Bangladesh Demographic and Health Survey (BDHS), merged with gridded data on ocean salinity from 1993 to 2018, we find that a one standard deviation increase in *in utero* salinity exposure leads to sizeable effects on the probability that a child suffers from chronic and acute nutritional deficiency. We also find evidence suggestive of an income channel. Using data on parental investments and health-seeking behavior, we show that, at least in the context of Bangladesh, there are no corresponding compensating behaviors to attenuate the detrimental effects of increased salinity. Using two complementary data sources providing agricultural and land-use variables, we find that the effects are partly mitigated through heterogeneity in the intensity of rain-fed agricultural activities. These results provide important quantitative evidence linking climate shocks, early life outcomes, and long-run human capital.

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1.0 Introduction

The effects of global warming, particularly coastal and tidal flooding, sea level rise, and shoreline recession, are becoming more salient in Bangladesh, a low-lying vulnerable country. The coastal belt of Bangladesh, home to more than 10 million poor people located in 19 districts (Dasgupta et al. 2018), is particularly hit by the natural hazards of climate change including sea water intrusion and progressive salinization of agricultural lands, largely impacting cropping intensity, yields, livelihoods, and human health.

While there is growing evidence that climate change contributes to the prevalence of acute and nutritional deficiency among vulnerable populations, there is still a need for a more accurate assessment of the effects of climate change, and of the potential channels of transmission that cause these impacts to generate disproportionately heavier health burdens for women and children. We attempt to address this research gap by empirically analyzing the impact of exposure to higher *in utero* salinity levels on children's nutritional status as measured by anthropometric measures.

To study how the variation in salinity levels during pregnancy shapes health in early life, we construct a novel dataset linking gridded data on salinity, weather, and ocean-chemistry variables, and child health outcomes. We obtain geo-referenced monthly data on sea water salinity and other variables related to the health of the ocean at a resolution of 0.083^0 x 0.083^0 (each degree corresponding to approximately 8 kilometers), from January 1993 to December 2019, from the Copernicus Marine Environment Monitoring Service (CMEMS). We then combine this data with children's standardized anthropometric measures (including the height-for-age, weight-for-height, and weight-for-age z-scores) from six geo-referenced waves of the Bangladesh Demographic and Health Surveys, and match the local variation in salinity to geocoded birth histories using the Inverse Weighting Method.

Leveraging a saturated fixed effects model that controls for the unobserved heterogeneity, including location-specific seasonality and regional trends, while conditioning on a host of child, mother, and household controls, we use the exogenous variation in the average salinity level of the 9 months preceding the child's month of birth to identify the impact on the child's health outcomes. We find that greater *in utero* salinity exposure leads to sizeable effects on the probability that a child suffers from chronic and acute nutritional deficiency. A one standard deviation increase in *in utero* salinity leads to a 0.114 standard deviation decline in the child's height-for-age z-score (representing approximately 6.6 % of the mean), while also increasing the prevalence of stunting and severe stunting by 0.75 and 1.30 percentage points, respectively. We obtain evidence of economically significant effects of increased salinity on the prevalence of wasting and malnutrition as well. These results withstand a battery of robustness checks using alternative measures of exposure, non-linear specifications, and additional ocean-chemistry controls. We also ensure that our results are not driven by selective fertility and migration. Overall, we obtain compelling evidence that higher salinity levels during pregnancy negatively impact child health outcomes.

We then undertake a careful exploration of possible mechanisms to gain additional insights into the channels through which salinity affects early life outcomes. We first examine heterogeneity in the effects across different sub-groups. We find larger negative effects for girls, non-first born children, and for children whose mothers were not employed. We then use the DHS information on parental investments and health-seeking behavior to evaluate whether parental investments react to the early childhood health shock caused by greater salinity exposure (guided by the literature on how parental investments respond to early life shocks – Almond and Mazumder 2013, Adhvaryu and Nyshadham 2016, and that prenatal shocks can be confounded by parental adaptation - Barker 1995, Currie and Almond 2011). We find that, at least in the context of Bangladesh, there are no corresponding compensating behaviors to attenuate the detrimental effects of increased salinity. Instead, we find that higher salinity levels are associated with lower prenatal and post-birth health-related investments, providing evidence suggestive of an income channel preventing women from using access to prenatal and post-delivery care as an adaptation strategy in a low-income country context in which coping mechanisms for adjusting to climate change are limited.

We then use two complementary gridded data sources providing agricultural and land-use variables to evaluate how the main effects are mitigated through heterogeneity in agricultural intensity. We obtain persuasive evidence that the harmful effects of increased salinity on agricultural yields and incomes are indeed underlying mechanisms for our main results. The effects of salinity on child health are driven by children living in clusters with lower agricultural intensity caused by the progressive salinization of lands. This means that poor nutrition and food insecurity are also potential mechanisms at work behind our main results.

Our work contributes to the body of scholarly work that considers the effects of various *in utero* shocks on early life health outcomes, human capital, and cognitive ability (Almond 2006, Bleakley 2007, Almond and Currie 2011, Almond and Mazumder 2011, Banerjee et al. 2010, Rocha and Soares 2015, Wilde et al. 2017, Adhvaryu 2019, Armand et al. 2021). It also speaks to a strand of the literature that quantifies the effects of climate change on a range of outcomes (Burgess et al. 2013, Barreca 2012, Deschenes and Greenstone 2011, Molina and Saldarriaga 2017), and that evaluates how environmental factors determine outcomes that in turn affect economic development (Dell et al. 2012, Maccini and Yang, 2009). Our work departs from the bulk of the literature by focusing on the country-specific ground realities to analyze the effects of climate change using high resolution temporal and spatial variation in salinity. This enhances our ability to make inference. We are thus able to use fine-grained data, in a baseline empirical specification that includes a set of fixed effects to control for seasonal characteristics and for geographic factors that may also be determinants of our outcomes of interest. The strength of our paper also lies in the use of a novel database that provides scope to understand the causal effects of climate change on human health, but also to tease out the combination of behavioral, parental, biological, and selection effects in a developing country context. Focusing on one region only – the coastal area of Bangladesh, allows us to fulfill the ceteris paribus condition that can be hard to achieve in cross-regional or cross-country studies.

Since there is consensus among policymakers and climate change experts that the deleterious effects of global warming will exacerbate preexisting vulnerabilities and inequalities in Bangladesh, it is essential to estimate the scarring effects of salinization on fetal health. Understanding how climate change related shocks impair child health is important, even more so to develop coping strategies in an environment with low adaptive capacity. Our findings have implications for policymakers and health stakeholders to focus more on the climate change induced diseases, thereby encouraging more cost-effective policies, given the high incidence of the increasing salinity phenomenon in Bangladesh.

Section 2 provides the background for our study, and it considers climate change, salinity, and human health in Bangladesh. Section 3 describes the data, the summary statistics, and provides evidence of increasing ocean salinity due to climate change. Section 4 provides details on the empirical strategy. Section 5 discusses the main results, and also provides results of robustness checks and alternative specifications. Section 6 investigates the potential mechanisms. Section 7 discusses selective fertility and migration, and section 8 concludes.

2.0 Background

2.1 Climate Change and Salinity in Bangladesh

Bangladesh, a low-lying deltaic country with a flat topography, is home to one of the largest populations regarded as the most vulnerable to climate change. Crisscrossed by the Brahmaputra, the Ganges, and the Meghna rivers, and located at the tip of the Bay of Bengal, the country is severely hit by sea level rise, tidal surges, shoreline recession, stronger cyclones, and riverbank erosion (Rahman et al. 2014). Coastal areas along the Bay of Bengal covering about 3.22 million hectares (Rahman et al. 2011), and more than 30% of the country's cultivable land (Rasel et al. 2013), and home to around 11.8 million poor people located in 19 districts (Dasgupta et al. 2018), are particularly hit by sea water intrusion and increased salinity levels.[1]

The southwest coastal region, lying about 1.5 meters above mean sea-level, is most threatened by climate-induced increases in water salinity. Annual mean sea level data for the period 1983-2003 from the Permanent Service for Mean Sea Level (PSMSL) shows that sea level in the southwest coastal region has increased from approximately 7007 mm in 1983 to 7129 mm in 2003, with a yearly average increase of roughly twice the global average per year of 3 mm over this 20-year period.[2] As a result, salt intrusion is also rapidly increasing in the coastal area. A report from the Soil Resource Development Institute (SRDI, 2010) from the Ministry of Agriculture, shows that salt-water intrusion has increased significantly from 2000 to 2009 because of sea level rise, and that the amount of salt-affected area (measured in hectares) during the nine years (2000-2009) and the four decades (1973-2009) in coastal areas has increased by 3.5% and 26.7%, respectively. Storm surges, the flow of saline groundwater during the dry season coupled with insufficient rainfall to lower the concentration of salinity on surface water, warmer temperature that increases evaporation, and tidal inundation in the wet season, all affect salinity in the coastal areas (Baten et

[1] The Bureau of Statistics in Bangladesh, the World Food Programme, and the World Bank, carried out a poverty-mapping exercise to estimate the population in coastal areas (Dasgupta et al. 2018).
[2] The data used is for station ID 1451 (Hiron Point, Bangladesh). More information can be obtained from psmsl.org. The data authority for this source is the Bangladesh Inland Water Department of Hydography, Transport Authority.

al. 2015, Dasgupta et al. 2016). These in turn largely impact the quality of livelihood, agricultural yields, cropping intensity, biodiversity, and human health.[3]

Higher salinity levels create a hostile environment for agricultural production, distort normal crop patterns, and impede economic development.[4] Heavy reliance on the agricultural sector implies that saltwater intrusion has significant ecological and socioeconomic implications for the coastal region, with possible spillover effects for the rest of the economy. Hossain et al. (2018) identify the main coastal communities affected by salt intrusion. Crop farmers, Sundarbans (mangroves) – dependent communities, and landless agricultural laborers, are highly vulnerable. Increased salinization causes drinking water shortages, food insecurity, degradation of soil quality, unemployment, reduction in tree coverage, and depletion of fish resources, all impacting negatively biodiversity and health. This means that enhanced salinity poses a serious threat to public health, lives, and livelihoods through its effects on ecosystems, access to freshwater sources, primary production, and aquaculture (Dasgupta et al. 2015). River and soil salinity in turn also hinder agricultural productivity and food security.[5]

2.2 Increased Salinity Exposure and Human Health

Increased salinity in the coastal belt of Bangladesh have nutritional consequences for women and children. The shortage of grazing land and fodder crops caused by progressive salinization leads to lower milk production, less cattle-raising, and other agro-biodiversity changes that have drastic effects on the households' diet and food habits, and deprive coastal households from major dietary sources of animal protein (Alam et al. 2017). Exposure to high levels of salt through drinking, bathing, and the expansion of shrimp farming to compensate for the loss of livelihoods cause several health problems, including hypertension, skin diseases, and miscarriages. The loss of

[3] Mahmuduzzaman et al. (2014) analyze the causes of salinity intrusion in the coastal region of Bangladesh. In addition to its critical geographic location and to climate change induced factors, sedimentation is a major cause of increased salinity in the coastal belt. The Ganges and the Brahmaputra are two highly sediment-laden rivers, and part of the sediment deposits on river beds or goes to the Bay of Bengal, reducing freshwater flow from stream, and causing waterlogging. Sedimentation in the tidal rivers causes upstream drainage congestion while allowing saline water to flow.

[4] The agricultural sector (agriculture, forestry, and fishing, value added) contributed 12.7 percent of Bangladesh's GDP in 2019, and employed 38.3 percent of the labor force (WDI, World Bank 2021).

[5] Baten et al. (2015) explain that irrigated water demand is very much impacted by saltwater intrusion in surface water. In turn, excess salt in soil affects plant growth in coastal areas. Rahman et al. (2011) consider the impact of salinity on agro-biodiversity in three coastal, rural villages of Bangladesh, and explain that the use of brackish water for irrigation severely limits the cultivation of rice and vegetables in the dry season.

income pushes vulnerable households into poverty, coupled with primary water sources being depleted by saltwater intrusion, and the loss of freshwater fish species, worsen nutritional deficiencies, and impact gestational hypertension, acute respiratory infections, diarrheal diseases, and mother-child health, in a region already suffering from chronic malnutrition levels. Khan et al. (2011), for instance, analyze the link between drinking water salinity and maternal health in Dacope, in the southwestern coastal Bangladesh, and find that pregnant women in this area had relatively higher rates of pre-eclampsia and gestational hypertension. Dasgupta et al. (2016) document the association between the mother's salinity exposure during the last month of pregnancy on infant mortality. Nahian et al. (2018) document the link between water salinity and health care crisis in coastal Bangladesh, while Joseph et al. (2019) find a U-shaped association between drinking water salinity and infant and neonatal mortality in Bangladesh.

3.0 Data

In this section, we describe the data sources. We provide summary statistics for the main variables used in the analysis, and consider the distribution and seasonality of ocean salinity.

3.1 Children's Health Outcomes

We use 6 rounds of geo-referenced Demographic and Health Survey (BDHS) for Bangladesh: years 1999, 2004, 2007, 2011, 2014, and 2017. The DHS is a stratified two-stage nationally representative sample. In the first stage, enumeration areas (EAs) are randomly chosen from the Population and Housing Census of the People's Republic of Bangladesh, and are used as the sampling frame, stratifying by region.[6] In the second stage, within the selected EAs (or clusters), a number of households are randomly selected to obtain reliable health and demographic variables.[7] We use anthropometric measures (the height-for-age z-score (HAZ), the weight-for-height z-score (WAH), and the weight-for-age z-score (WAZ)) for all children aged 0-5, collected in households within which women of reproductive age (15-49 years) were interviewed. We create indicator variables for stunting, wasting, and undernutrition using these measures. We also complement the early childhood outcomes with additional child and household characteristics and

[6] Bangladesh has 8 administrative divisions: Barishal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet. Each division is further divided into *zilas*, and *zilas* in turn contain *upazilas.*

[7] For instance, in the 2017-18 DHS, the primary sampling unit (psu) of the survey is an average of about 120

other health-related measures. We use the geographic location of each surveyed cluster to match the DHS cluster to our geo-coded salinity and weather data.[8]

3.2 Identifying DHS Coastal Communities

To identify the DHS clusters that are most likely to be affected by the rising sea water salinity phenomenon, we use a measure of proximity to the ocean's shore. For each DHS cluster, we calculate the minimum straight distance between the cluster's location and the closest shoreline, using the Global Self-Consistent, High Resolution Geography Dataset (GSHHG), developed and maintained by Paul Wessel and Walter Smith (Wessel and Smith, 1996), to obtain the shoreline polygon data. We then use the standard definition based on geography (distance from the shoreline) to identify coastal clusters, and we follow the recent literature to narrow down the definition to vulnerable coastal clusters. We define coastal communities as those living within 100 km from the ocean, and we classify households living in DHS clusters within 40 km from the ocean as being the most vulnerable communities directly exposed to climate change induced increases in ocean salinity.[9]

3.3 Ocean Salinity and Chemistry

Our ocean salinity and chemistry data comes from Copernicus Marine Environment Monitoring Service (CMEMS), which is drawn from both satellite Earth Observation and *in-situ* (non-space) data.[10] The gridded dataset has a spatial resolution of 0.083° x 0.083° (approximately 8 km * 8km) and vertical coverages of 50 levels (from the sea level to 5,500 meters deep), includes data on daily and monthly salinity, temperature, currents, mixed layer depth, sea surface height, and ice parameters, for the period January 1993 to December 2019.[11]

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households. In the first stage, 675 EAs (425 in rural areas and 250 in urban areas) were selected with probability proportional to EA size. In the second stage, a systematic sample of an average of 30 households per EA was selected.

[8] DHS clusters contain sensitive information, and to maintain respondents' confidentiality, the urban and rural clusters are displaced up to 2 to 5 kilometers, respectively.

[9] We here follow Armand et al. (2021) who provide an empirical assessment of rising acidification on early-childhood mortality.

[10] We use the global ocean 1/12° physical reanalysis (GLORYS12V1) product: "global ocean eddy-resolving reanalysis covering the altimetry".

[11] The "Global_Reanalysis_PHY_001_030" product contains three datasets (the 3D daily mean fields, monthly mean fields, and monthly climatology mean fields). We use the dataset containing monthly mean fields. For more information on the validation methodology and series of diagnostics used for the dataset, see Drevillon et al. (2018).

We obtain monthly measures on seawater salinity, seawater potential temperature, sea surface height, eastward and northward seawater velocity, and the ocean's pH levels from 1993 to 2019.[12] Specifically, our salinity metric measures as the amount of dissolved salts in parts per thousand and is commonly reported in Practical Salinity Units (PSU). We match this data to the geolocation of DHS clusters using the month and year of birth of each child using inverse distance weighting (IDW). We elaborate more on this approach below.

3.4 Weather Data

Since other features of daily weather could be correlated with both children's health outcomes and salinity levels, we include a series of climatic variables to address potential omitted variable bias.[13] We obtain weather data from the Bangladesh Meteorological Department (BMD), the national meteorological organization of Bangladesh under the administrative control of the Ministry of Defense. Amongst other responsibilities, the BMD maintains historical records of all meteorological events, and archives weather and climate data. We obtain station-month-year level data for 35 stations across Bangladesh from 1970 to 2019, including data on minimum and maximum temperature, rainfall, and humidity.[14]

To transform the weather data from station level to the cluster level, we use inverse distance weighting (IDW) following the environmental economics literature (e.g., Mendelsohn et al. 1994, Deschenes and Greenstone 2011, Zhang et al. 2017). We calculate the weighted average of the weather data for the 5 closest stations for each cluster, weighing each point by the inverse of the squared distance from the cluster's centroid. Thus, for each month and year, we estimate each cluster's weather data as the weighted average of stations' data readings, with the weights being

[12] The original file format is the Network Common Data Form (NetCDF) and NetCDF-4. We process these files in Python to obtain month-year level data from January 1993 onwards. All variables considered here are on the same regular grid points.

[13] The literature suggests that climate change affects the distribution of several climatic variables, and that any model that attempts to evaluate the distributional effects of climate change will most likely produce biased results due to omission of a set of other climatic variables. Barreca (2012) for instance, finds that humidity, like temperature, is an important determinant of mortality. Zhang et al. (2017) finds that omitting humidity tends to over-predict the cost of climate change on crop yields.

[14] Auffhammer et al. (2013) and Zhang et al. (2017) highlight the importance of having a continuous weather record (and thus few missing observations) when averaging station-data across space to ensure relatively lower loss of weather variation when fixed effects are used in the empirical model. We use spatial interpolation to fill in the few missing observations. We use the IDW method using the closest 1, 3, 5, and 10 closest station points as well as linear regression to impute the missing values, and compare the results using the root mean squared error (RMSE) and the out-of-sample R-squared. Our results suggest that estimating the missing values using IDW with the 10 closest points minimized the errors in this case.

inversely proportional to squared distances so that each station has a local influence that diminishes with distance.

Let c denote a DHS cluster, i a station, and n_c is the number of stations that relate to cluster c (we choose $n_c = 5$). Let d_{ic}^2 be the squared distance between cluster c and station i. We thus define the weight W_{ic} as follows:

$$W_{ic} = \frac{\frac{1}{d_{ic}^2}}{\sum_{k=1}^{n_c} \frac{1}{d_{kc}^2}} \quad for\ d_{ic} \geq o, and\ for\ any\ i, c$$

Thus, temperature $\bar{T}_c$ at cluster c equals to:

$$\bar{T}_c = \sum_{i=1}^{n_c} W_{ic} T_{ic}, \qquad \text{with} \sum_{i=1}^{n_c} W_{ic} = 1$$

Where T_{ic} is the temperature at station i related to cluster c. Simply, T_{ic} is weighted by the inverse of the squared distance given the mean temperature at station i (see De Mesnard (2013) for more details for the use of the IDW method in models estimating pollution impact, for instance).

We also interpolate cluster estimates using 1, 3, and 10 closest stations to test for robustness. We assign these weighted averages to each cluster, and we include the average minimum and maximum temperature, rainfall (and interaction terms with temperature), and humidity in the month and year of birth in all regressions to account for their potential confounding roles.

3.5 Summary Statistics

Table 1 provides the summary statistics for the variables used in the empirical analysis. In Panel A, the mean HAZ is -1.804, and approximately 45% and 19% of children aged 0-5 years being stunted and severely stunted. The mean for WAH and WAZ are -0.910 and -1.671, respectively, and almost 15% and 39% of children in our sample of vulnerable coastal communities are wasted or underweight/undernourished, respectively.[15]

[15] Figure A1 in the appendix shows that there is substantial heterogeneity in the nutritional status of children across sub-districts in Bangladesh. Our data also reveals that in coastal areas, there is a higher prevalence of children suffering from acute and chronic nutritional deficiency.

In Panel B, the mean for our variable of interest, the average salinity level during the 9 months preceding the child's month of birth, is 12.591 psu, with a standard deviation of 4.396. Ocean's pH has an average of 8.199. Panel C reports the summary statistics for weather-related variables used as controls in all our regressions. Panel D provides information on the characteristics of children and mothers in our sample. Half of the children are boys, and the average age is 29.3 months. The average birth order is 2.69, and the average mother's age at first birth is 18 years. On average, 30% and 39% of mothers in our sample had completed primary and secondary education only, respectively. In 87% of cases, the head of the household is male. All the variables shown in panels C and D of Table 1, and ocean's pH are included as controls because these are potential determinants of child health.

3.6 The Distribution and Seasonality of Ocean Salinity

The kernel densities for average salinity levels in panels A and B of Figure 2 provide evidence of climate-induced change in ocean salinity over time. Both panels consider the kernel densities for salinity levels for ocean points associated with the DHS clusters within 100 km of the ocean for the three equal periods: 1995-2002, 2003-2010, and 2011-2018. Panel B includes only salinity for ocean points associated with the sampled southwestern coastal DHS clusters for the same three periods. Climate change shifts the distribution of ocean salinity to the right, with a more evident shift for southwestern coastal communities in Panel B, which clearly shows how climate change has altered the bimodal distribution of salinity, with a change in the peaks from 1995 to 2018, suggesting that this region experiences higher levels of salinity, with measurable changes in particular over the last period 2011-2018.[16]

Ocean salinity clearly varies with the onset and end of the monsoon period. Panel A of Figure 3 shows the seasonal variation in salinity (the average for each month over the years) for ocean points matched to all DHS coastal clusters, and for southwestern coastal clusters sampled. We can observe the critical difference in salinity in the pre-monsoon and post-monsoon seasons. It generally increases in the post-monsoon period (October) until the pre-monsoon month of May, after which it falls drastically. Salinity is higher in the dry season when lower rainfall and warmer

[16] Given that temperature, rainfall, and humidity have also been trending upwards over time in Bangladesh, the climate change-induced effects on ocean salinity levels are very much likely to have major implications for agricultural resources and income, and for the nutritional intake of vulnerable households.

temperatures cannot counteract the higher concentration of salinity on surface water (Baten, 2015), and saline water intrudes through the major rivers through tidal effects (Shammi et al. 2019, Dasgupta et al. 2015). Increases in the ice melting of the Himalayas during the monsoon period (May to October) generates a higher upstream flow of freshwater, higher river water discharge, and thus reduces salinity in the coastal areas (Mahmuduzzaman et al. 2014). It reaches a minimum usually in September/October in the wet season as seen in Panel A of Figure 3. We note also in Panel A that while salinity exhibits a similar seasonal pattern in the southwestern coastal area, saltwater intrusion threatens this region relatively more given the higher average salinity levels in any given month.[17]

Panel B of Figure 3 shows the distribution of ocean salinity for ocean points matched to (i) all sampled coastal clusters, and (ii) southwestern coastal clusters. Salinity is skewed to the right when all coastal clusters are considered, and there is substantial variation, with many clusters having salinity levels lower than 10 psu. However, the distribution of salinity in the southwestern region is different. There is again much cross-cluster variation but many southwestern clusters are matched to salinity levels greater than 15 psu, and even reaching higher levels of more than 25 psu. These two distributions also reveal that while the southwestern region represents a smaller subset of individuals being affected by rising salinity, the identifying variation also stems from the majority of clusters, and not from a few outliers only. Taken together, Figures 2 and 3 reveal that ocean salinity exhibits substantial variation across clusters and over time.

4.0 Empirical Strategy

To test for the effects of variation *in utero* salinity on early life health outcomes, we use the following benchmark specification:

$$y_{icdmt} = \beta salinity_{cdmt} + X'_{icdmt}\gamma + \mu_d + \sigma_m + \lambda_t + \eta_{mt} + \theta_{dm} + \Phi_{dt} + \epsilon_{icdmt} \qquad (1)$$

y_{icdmt} is the health outcome for child *i*, born in month *m* in year *t*, and whose mother was surveyed in cluster *c* in district *d*. The outcomes of interest are continuous for HAZ, WAH, and WAZ. The binary variables *stunted* and *severely stunted* equal to one if the child's HAZ falls below -2 and -3 standard deviations from the median HAZ, respectively. Similarly, *wasted* and *severely wasted* are binary variables that equal to one if the child's WAH falls below -2 and -3 standard deviations

[17] The monthly averages depicted in Panel A of Figure 3 hides substantial cross-cluster variation.

from the median WAH. *Underweight* and *severely underweight* are constructed from the WAZ in a similar fashion, following the World Health Organization guidelines.

We restrict the sample to all coastal communities living within 100 km and within 40 km from the ocean. We consider the effects of salinity exposure in the *in utero* phase, and construct $salinity_{cdmt}$ as the average ocean salinity of the 9 months preceding the child's month of birth for cluster c as our main variable of interest.[18] β is the coefficient of interest, and it is expected to be negative for HAZ, WAH and WAZ, and positive for *stunted* and *severely stunted*.

X_{icdmt} is a vector of controls, including child, mother, and household characteristics, and time-varying weather and ocean chemistry controls that could potentially be correlated with salinity while also determining part of the variation in early life health outcomes. In our preferred specification, we include child's age, gender, and birth order, mother's age at first birth, three dummy variables for the mother's education (primary, secondary, and tertiary, with no education at all being the excluded category), mother's height, and the gender of the household head. We also include a host of time-varying climatic variables: minimum and maximum temperature, rainfall (in logs), the interaction between minimum/maximum temperature and log of rainfall, and humidity. We also control for ocean pH, and consider additional ocean chemistry controls including seawater velocity, seawater potential temperature, sea surface height in our robustness analysis.[19]

We include a series of temporal and spatial fixed effects to control for the unobserved heterogeneity, including seasonality and regional trends, as ocean salinity varies predictably across time and space.[20] District fixed effects (μ_d) account for the unobserved time-invariant characteristics specific to the districts in which the clusters are surveyed, and allow us to control for geographic characteristics that may determine child health. We include month of birth fixed effects (σ_m) to account for other seasonal factors that may affect child health even more so because salinity varies greatly between seasons in Bangladesh. Year of birth fixed effects (λ_t) and year by month fixed effects (η_{mt}) are included to control for the idiosyncratic changes in child health

[18] Here we implicitly assuming that the gestation period is 9 months for all children since we

[19] We also use the average of these variables 9 months prior to birth to control for exposure for the same period as for salinity (assuming again a gestation period of 9 months).

[20] As such, we use the deviation of salinity from the long-run seasonality and trend at the location of birth (as in Armand et al. 2021).

outcomes that could be common across clusters (and thus for nationwide seasonality in economic conditions, health, and climate). We also include district fixed effects interacted with month of birth (θ_{dm}) to control for the local seasonal variation in both ocean salinity and patterns in children's nutritional status, and so to absorb differences in seasonality of child health across districts that could be correlated with ocean salinity seasonality. Φ_{dt} are the district-year of birth fixed effects (the interaction between year of birth dummies with district fixed effects) to control for district-specific trends in cohort nutritional status, and thus for any annual pattern in health outcomes that may differ across districts.[21] ϵ_{icdmt} is the idiosyncratic error term. Regressions are weighted to ensure that the sample is representative and to adjust for the selection of a single woman per household. We report robust standard errors clustered at the DHS cluster level.

The identifying assumption is that there are no omitted variables that could correlate with both our salinity measure and with the child health outcomes, so that the assignment of exposure to salinity levels *in utero* is determined only by the differential birth timing of children from the same cluster, and is therefore as good as random. Identification of the parameter of interest, $\beta,$ therefore stems from the variation in salinity exposure that cannot be explained by weather and ocean chemistry controls, district-specific trends and seasonality, and other sources of unobserved heterogeneity considered in the main specification.

5.0 Main Results

5.1 The effects of increased *in utero* salinity exposure

In Table 2, we present results from our benchmark regression in equation (1). In Panel A, we restrict the sample to the vulnerable coastal area (DHS clusters living within 40 km of the ocean), and in Panel B, we restrict the sample to all DHS clusters living in the coastal area, that is within 100 km of the ocean. Focusing on the coefficients in Panel A, we see consistently negative effects of ocean salinity on children's nutritional outcomes for the standardized anthropometric measures. In column (1), the height-for-age z-score (HAZ), a measure of chronic nutritional deficiency, is negatively impacted by a rise in *in utero* salinity exposure. A one standard deviation increase in *in*

[21] This allows us to control for possible omitted variables that could play a key role because children born in certain months, years, districts, are more likely to be exposed to different salinity levels, and to unobserved determinants of their future health.

utero salinity leads to a 0.1139 standard deviation decline in the child's HAZ (representing approximately 6.6 % of the mean). In columns (2) and (3), the binary variables for stunted and severely stunted are equal to one if the child's HAZ is below -2 and -3 standard deviations, respectively. The results on these two variables are in line with our expectations – *in utero* salinity exposure has sizeable effects on the probability that the child is stunted and severely stunted. A one unit increase in salinity increases the prevalence of stunting and severe stunting by 0.75 and 1.3 percentage points, respectively. Taken together, results in columns (1) to (3) in Panel A imply that variation in *in utero* exposure has implications for children's health outcomes, and that the negative effects are not transitory in nature. We also note in Panel B that when the sample is restricted to all coastal communities, the coefficients are of smaller magnitudes, insignificant in columns (1) and (2), but that higher *in utero* salinity exposure still increases the prevalence of severe stunting significantly (as seen in column (3) of Panel B).

In columns (4) to (6), we consider the effects on the measures of acute nutritional deficiency using the weight-for-height z-score (WAH), and binary variables for wasted and severely wasted (that equal to one if the child's WAH falls below -2 and -3 standard deviations, respectively). Column (4) of Panel A suggests that the effect of a one standard deviation increase *in utero* salinity leads to a 0.1262 standard deviation decrease in WAH (representing approximately 13.9 % of the mean), with economically and statistically significant effects on the prevalence of wasting and severe wasting. We obtain significant coefficients of slightly lower magnitudes in columns (4) to (6) of Panel B when we consider the sample of all coastal communities.

In columns (7) to (9), the dependent variables relate to the weight-for-age z-score (WAZ) (as a continuous variable in column (7), and as binary indicators for underweight and severely underweight in columns (8) and (9), respectively), as the main measures for the child's growth process and degree of malnutrition. The results again support our hypothesis that variation in *in utero* salinity levels have detrimental effects on children's health outcomes. Higher *in utero* salinity levels are associated with lower WAZ, and higher prevalence of children who are underweight and severely underweight, even after the inclusion of child, mother, household controls, potential weather-related confounding variables, and a host of fixed effects. Since WAZ is a composite measure of both chronic and acute nutritional deficiency, the negative effects of salinity presented here suggest that increased salinity levels have important implications for future human capital accumulation as well.

5.2 Robustness checks for the main results

5.2.1 Alternative Measures of *in Utero* Exposure

It is possible that the intensity, variability, and accumulated salinity exposure also drive the variation in child health outcomes documented above. We construct alternative measures of *in utero* exposure (following Adhvaryu et al. 2020) to underline the robustness of our main results.[22] In Panel A of Appendix Table A1, the results on the child health outcomes remain robust when we use the accumulated salinity level (in logs) for the 9 months prior to birth as the main source of variation. In Panel B, we keep the average *in utero* salinity as the main variable but control for the number of months in which salinity exceeded the cluster's mean (by at least one standard deviation) as a measure of intensity. The estimates for the main variable of interest are in the same ballpark as those from the main analysis (albeit rendering the coefficient in column (9) still positive but not significant). In Panel C, we use the standard deviation of salinity for the 9 months before birth as the main measure of variability. The results suggest that higher salinity dispersion is also associated with deteriorating child health outcomes, with significant effects on the likelihood that the child is severely stunted, severely wasted, underweight, and severely underweight. Given the unique distribution of salinity in the southwest coastal region, we exclude the southwestern districts from the sample of vulnerable coastal areas in Panel D to ensure robustness. The coefficients now have slightly different magnitudes but still match our a priori expectation that increased *in utero* salinity exposure leads to deteriorating child health outcomes. In panel E, we assume a gestation period of 10 months, and use the average salinity level 10 months prior to birth. Overall, our main results withstand a battery of robustness tests related the measure of salinity exposure.

5.2.2 Additional Controls for Potential Confounders

Our identifying assumption implies that there are no omitted variables that could be correlated with *in utero* salinity exposure and with our health outcomes, so that variation in salinity is exogenous to unobserved factors affecting the dependent variables. In Table A2, we augment our

[22] We focus on the results for vulnerable coastal areas (within 40 km of the ocean) henceforth but results for all coastal communities (with 100 km of the ocean) are available upon request.

baseline specification with additional controls related to ocean chemistry to account for the possibility that salinity is acting as a proxy for changes in other ocean-related characteristics. We control for seawater temperature, sea surface height, and for eastward and northward seawater velocity, all measured as averages for the 9 months prior to birth. As such, the specification used in Table A2 provides the effect of *in utero* salinity conditional on other ocean chemistry variables. Controlling for these additional variables does not render our main results on *in utero* salinity exposure insignificant.

5.2.3 Non-Linear Specification

In Appendix Table A3, we replace our variable of interest with binary variables constructed using the sample distribution of salinity in the vulnerable coastal area to account for non-linearities in the effects of salinity. In Panel A, the variable of interest is an indicator variable that equals to one if salinity is greater or equal to the 50th percentile (the median in the data).[23] We note that when this binary variable is used, the results suggest that children exposed to above median *in utero* salinity levels are more likely to experience deteriorating health outcomes. In Panel B, we use quartiles of salinity exposure, and include three binary variables that each equals to one if the child experienced *in utero* salinity levels is in the second, third, or fourth quartile.[24] The results show that relative to the lower quartile exposure (the omitted category), children in the third and fourth quartiles have lower HAZ, WAH, and WAZ, and higher prevalence of stunting, wasting, and underweight. The point estimates are higher for the top quartile indicator variable. In Panel C, we once again exclude the southwestern districts from the sample, and check that our results are not dependent on the linear specification used in the core part of our analysis. All the coefficients are again of higher magnitudes for the top quartile indicator.

5.2.4 Results by Trimester of Gestation

We also explore whether the impact of *in utero* salinity exposure differs by trimester of gestation, which has been shown for other types of chemical and environmental exposures. We thus

[23] This corresponds to a salinity of 11.3 psu in the data.
[24] For the lower quartile, salinity ≤ 9.3 psu, second quartile: 9.3-11.3 psu, third quartile: 11.3-15.4 psu, and for the top quartile: ≥ 15.4 psu.

disaggregate the exposure variable by trimester to understand whether there are gestational periods in which the effects of salinity are more pronounced.[25]

The results are presented in Appendix Table A4., and we find differential impacts between different stages of exposure to salinity. Stunting is mainly caused by exposure to salinity in the second trimester: a one-standard-deviation increase in salinity exposure in the second trimester decreases HAZ by 0.174 standard deviation, the chance of stunting by 0.8 pp, and the chance of severely stunting by1.0 pp. Exposures to salinity in the first and third trimester have statistically insignificant effects on stunting. Wasting is mainly caused by exposure to salinity in the first trimester: a one-standard-deviation increase in salinity exposure in the first trimester decreases WAZ by 0.288. Exposure in the second trimester has no significant impact on WAZ or wasting, and exposure to salinity in the third trimester increases the chance of severe wasting, though has no statistically significant impact on the WAZ index or the chance of wasting. The results on underweight are statistically noisy: we find negative point estimates on WAZ, and positive point estimates for the probability of underweight and severely underweight for exposure from all three trimesters, but only the effect of second trimester exposure to salinity on WAZ is statistically significant.

Given the nutritional effects of salinity entangled with several other biological and parental forces, it is possible that the effects of salinity carry various implications beyond the first semester, so that average exposure during the full gestational period matters.

5.2.5 Timing of Exposure: Controlling for Salinity Before Conception and After Birth

As a falsification test, we check for whether the impact of salinity exposure pertains only to the *in utero* period, or do exposure before or after the *in utero* period also have effects. In Appendix Figure A2, we present results estimating the effects of salinity during the pregnancy period by including average salinity levels 1-2 months before conception (10-11 months before birth), 3-4 months before conception (12-13 months before birth), during the month of birth, and 1 trimester after birth. We note that conditioning on *in utero* exposure, exposure before or after pregnancy does not have statistically significant effects for most of the outcome variables, with the exception

[25] This involves estimating a variant of our baseline model in equation (1), where $\beta salinity_{cdmt}$ is replaced with three variables for the mean salinity exposure during the first, second, and third trimesters. In other words, $\beta salinity_{cdmt}$ is replaced with $\sum_{k=1}^{3} \beta_k salinity_{cdmt}$ for each trimester k.

in panel A, where we notice that the coefficient on *in utero* salinity becomes marginally significant while salinity in the month of birth determines part of the variation in HAZ.

6 Mechanisms

6.1 Heterogeneous Effects of Salinity Exposure

We now explore the heterogeneity in the impacts of *in utero* salinity exposure on child health by child, maternal, and locational characteristics. Results are presented in Table 3. In Panel A of Table 3, we first estimate impacts by gender of the child. The results using sub-samples restricted to female children point to larger negative effects of *in utero* salinity on almost all health outcomes. In the case of stunting, girls are significant impacted by salinity exposure (HAZ index and the probability of being severely stunted), while boys are not. This effect for gender heterogeneity can be explained by two factors. It could be that there exist gender-biased early childhood health investments by parents (Bharadwaj et al. 2020) in favor of boys (a possibility that we explore deeper in the following section). The fall in income caused by progressive salinization could affect prenatal care and health-seeking behavior adversely, thereby affecting girls' health disproportionately. Secondly, it could be that the high vulnerability of male fetuses to adverse shocks lead healthier boys who survive to have better health outcomes post-birth (Gualtieri and Hicks 1985, Kraemer 2000, Sanders and Stoecker 2015).

In Panel B, we consider the heterogeneous effects of salinity across birth orders. The results suggest that while salinity has a detrimental impact on all children in our sample of coastal communities, non-first-born children are more negatively affected relative to first-born children such that they are more likely to be wasted or underweight. The point estimates on stunting is similar in magnitude (for HAZ and probability of being stunted). This does not necessarily align with the idea that parental experience would generate offsetting effects for later-born children that could mitigate at least partially the damaging effects of salinity. This is likely due to an intrafamily resource constraint, such that when the number of children in the household increases, parental investments decrease (Becker and Tomes 1976; Li, Zhang, and Zhu 2008).[26]

[26] We obtain some evidence that the negative effects of salinity on prenatal care and at birth investments are more pronounced for non-first children in the following section.

We then use mother's height as an indicator of mother's health in Panel C. We split the sample on the median for mother's height, and we would expect stronger impacts of salinity for children whose mothers have below sample median height (those who are shorter and in relatively poorer health). We find that all coefficients maintain their signs, suggesting that children in both groups are at risk, but we do not find evidence that children of mothers who are shorter are actually more affected by salinity. In the last panel, we run separate regressions for the sample of children whose mothers were working outside jobs versus those who were not. We obtain statistical significance mostly for children whose mothers did not work. There is no corresponding significant impact for salinity on most health outcomes (except for stunting and severely wasted) for children whose mothers were employed. Children of unemployed mothers are more exposed to the health damages of salinity. Working mothers possibly have access to the health-related knowledge and care to protect their children better, or have recourse to strategies that can mitigate the harmful effects of higher levels of *in utero* salinity, thereby enhancing their ability to respond to shocks with compensatory investments.

In Table 4, we consider separate regressions for sub-samples created based on location characteristics. In Panel A, we find that the response of health outcomes to a certain level of salinity exposure is greater mostly in areas with population density below the sample median. Since population density can act as a partial proxy for urbanization, it means that the effects of increased salinity is evident mostly for most rural coastal communities. Our results in Panel B of the same table lend support to this finding. We use the total built-up area (measuring the number of towns, cities, and other buildings in squared km per grid cell) as a proxy for urbanization.[27] Children living in coastal areas with more 'built-up' areas are less affected by exposure to salinity. In Panel C, we test whether heterogeneity in exposure to another ocean-chemistry variable can drive part of the main results. Higher vulnerability is observed among children exposed to higher pH levels. This means that in areas characterized by both higher salinization and acidification, climate change is likely to have more significant adverse effects on child health outcomes.

6.2 Early Childhood Health Investments

In this section, we test for whether the effect of salinity on child health is intensified, or mitigated, by (the lack of) compensating behaviors from parents. Parental investments and behavioral

[27] The data is available from HYDE 3.2, a data source on which we elaborate further in the paper.

responses are documented as possible mechanisms that affects the magnitude of impacts of environmental exposure on early life outcomes (Almond and Mazumder, 2011). In Panel A of Table 5, we examine the impact of salinity on vaccinations undertaken after birth. All the coefficients are negative (and insignificant only in columns (3) and (4) for BCG and DPT 1), suggesting that increased salinity exposure negatively impacts early childhood investments in the context of a salinity-vulnerable developing country. This finding also reinforces the evidence suggestive of an income channel. Water and soil salinization in the coastal communities leads to crop failure, creates water crises, destroys employment opportunities, and lowers agricultural income. This could indeed hinder women's ability to make health-related investments in both the prenatal and postnatal stages, especially for the weakest children. Increased opportunity cost of maternal time (Bhalotra et al. 2010, Bharadwaj et al. 2020) due to livelihoods losses could also explain the fall in vaccination rates, even when child quality is revealed. Our findings here suggest that greater salinity exposure impedes early life health investments.[28]

In Panel B of Table 5, we test directly for compensating behaviors by considering how greater salinity exposure during pregnancy affects the number of antenatal visits, prenatal care, medical assistance during delivery, and institutional delivery. In columns (1) and (2), we find that higher salinity negatively impacts the number of antenatal visits reported by the mother and lowers the likelihood of receiving iron tablets during pregnancy.[29] In columns (3) to (6), we code the dependent variable as equal to one if prenatal care and medical assistance at birth came from either a doctor or a nurse, respectively. Again, we obtain negative and statistically significant effects on all outcomes. In column (7), *'delivery at home'* equals to one if the mother reports that she has given birth at home. Greater salinity raises the likelihood of delivery happening at home. Since decisions pertaining to prenatal care and at birth investments are made before birth, it means that higher *in utero* salinity levels are also coupled with reduced investments onto healthcare. This also means that compensatory prenatal care is not being used as an effective adaptation strategy (as documented in Banerjee and Maharaj 2020). On the contrary, the impact of salinity is transmitted

[28] The literature provides mixed evidence on health shocks, compensating behaviors and parental investments. Molina and Saldarriaga (2017) find negative effects of heat shocks on medical assistance at birth in the Andean region. Armand et al. (2021) do not observe any significant effect of ocean's chemical composition on antenatal and delivery investments. Adhvaryu et al. (2019) find that health investments reduce the effects of *in utero* dust exposure in West Africa.

[29] The number of antenatal visits also determines the use of nutrient supplementation during pregnancy (Gebremedhin et al. 2014).

through lower investments to healthcare, both before and after observing the child's early developmental outcomes.

Given the existing evidence on the importance of gender and birth order in explaining differential behavioral responses to adverse shocks (Baird et al, 2011), we examine whether the effects of salinity on health-seeking behavior are homogenous in the child's gender and birth order. The results are reported in Appendix Table A5 for different sub-samples used in separate regressions. We find that greater salinity levels clearly discourage early investments in child health in Panel A and prenatal care and at birth investments in Panel B, irrespective of gender and birth order. However, we also note that in Panel B, we obtain statistical significance mostly for the sub-sample of non-first born children and higher negative estimates in columns (1), (2), and (4) for girls. Taken together with our findings on the heterogeneous effects of salinity in section 6.1 for girls and non-first born children, these additional results imply that salinity may cause gender-biased parental investments in Bangladesh.

6.3 Agricultural and Biodiversity-Related Losses

Increased salinity in the coastal belt of Bangladesh affects child health through its negative impacts on agriculture, biodiversity, and on the availability of fresh water for consumption (Dasgupta et al. 2015). Significant reductions in agricultural yields, accompanied with ground water and soil quality degradation (Khanom, 2016), largely affect livelihoods.[30] The loss of native species, the fall in productivity, and in the availability of agricultural land, all contribute to heightened food insecurity.[31]

Given the limitations of the available data, it is difficult to disentangle all the possible mechanisms that could be behind the effects of increased salinity on health outcomes. Here, we attempt to examine empirically the agricultural and bio-diversity related mechanism, guided by the intuition that salinization of agricultural lands may have cascading effects on health via its impact on crop systems, aquaculture (including the Sundarbans, mangroves), livestock, and homestead agro-

[30] This has caused aquaculture to boom over the past few decades as coastal communities adapt to increased salinity by relying more on shrimp cultivation. This in turn worsens the soil salinity problem further as brackish water invades surrounding areas, and leads to a fall in the number of indigenous rice varieties (Rahman et al. 2011).

[31] Ziaul Haider et al. (2013) study the impact of salinity on farmers' livelihood strategies in four villages of the Satkhira district. They find that while the salinity problem encourages shrimp cultivation, other land-use activities, and changes in agricultural patterns as measures of adaptation, it still has detrimental effects on agricultural income and employment opportunities, leading to lower living standards.

forestry. As such, exposure to salinity exposure serves as an income shock, which could deteriorate children's health outcomes through channels like increasing food insecurity and reduced healthcare affordability. We use two complementary data sources that provide gridded agricultural/land-use variables to evaluate empirically the heterogeneous effects of *in utero* salinity exposure on child health outcomes based on agricultural outcomes.

We first use the Copernicus Land Monitoring Service (CLMS) to obtain land cover classifications for the period 1993-2019. The annual land cover maps available at 300m (0.002778^0) spatial resolution for 2016-2019 are based on the PROBA-V satellite. They are consistent with the annual land cover maps from 1992-2015 produced by the ESA-CCI LC project (Defourny et al. 2017). Using the coordinates of each DHS cluster, we create buffer zones of 5, 10 km, 20 km, and 30 km, and count the total number of each land-use class within each buffer zone to track land-use patterns over space and time.[32] Appendix Figure A2 presents an example of the procedure for the 1999 DHS clusters. It shows the land cover map for 1993, which we superimpose to a shapefile containing the coordinates of the DHS clusters as of 1999. Geolocation of DHS clusters is used to match birth histories (that is, based on the child's birth year) with land-use patterns.

We first build indicator variables to control for whether the cluster has a measure of land-use activities that is below or above the sample median. We augment equation (1) with these new proxies to unveil the agricultural/bio-diversity channel relating salinity to child health.[33] In Panel A of Table 6, we augment equation (1) with an indicator variable that equals to one if the proxy for agricultural activities (including rain-fed and irrigated cropland) is below the sample median value in the child's cluster and in his year of birth. We note that when we condition on this variable, the coefficients on salinity are now of lower magnitudes, with the results for stunting (column 2) and severely underweight (column 9) becoming statistically insignificant. The signs of the coefficients on the dummy variable 'cropland' are in line with our expectations – children living

[32] To proxy for agricultural cultivated area, we aggregate the IPCC classes representing rain-fed cropland and irrigated cropland. To proxy for forestry area, we aggregate the IPCC classes representing tree cover (broad-leaved, needle-leaved, evergreen and deciduous). We also focus on the tree cover flooded with saline water, and on other land-use classes for shrub land, grass land, sparse vegetation, other bare areas, and water. For further details, see the correspondence between the IPCC land categories used for the change detection and the LCCS legend used in the land cover classes provided by the Land Cover Climate Change Initiative - Product User Guide v2. Issue 2.0.

[33] To account for possible spillovers, we report the results using the land-use proxies in a buffer of 30 km. Results using other buffer zones are available upon request.

in clusters experiencing lower agricultural activities (and possibly more hampered crop yields due to salinity) have deteriorating anthropometric measures (these effects are statistically significant at least at the 5% level for severely stunted, underweight, and severely underweight).

In Panel B of Table 6, we add two other land-use variables to analyze the impact of salinity on child health when proxies for agro-diversity are accounted for. *'forest'* is a dummy variable that equals to one if the cluster has below median tree cover. *'trees flooded with saline water'* is a dummy variable equal to one if the cluster has above median tree cover with saline water. Again, we note a fall in the magnitudes of all coefficients on salinity. While the coefficients on *'forest'* are mostly insignificant, those on *'trees flooded with saline water'* are statistically and economically significant in columns (1), (3), and (7) to (9).[34] Taken all together, results presented in Table 6 provide the first set of evidence that the strong intensity of water and soil salinity causing crop failure, agricultural and biodiversity losses, are indeed potential channels of mechanisms.

As an immediate robustness check on these findings, we estimate a variant of equation (1) by including an interaction term between salinity and *'cropland'*, while still controlling for other land-use variables included in Panel B of Table 6. The results are reported in Appendix Table 6. The coefficients on the interaction term are significant for WAH, WAZ, and for wasting and underweight. We also find that most of the coefficients on salinity are now of lower magnitudes (and of lower statistical significance) once the interaction term is included together with the other land-use proxies. In Panel B of Table A6, we restrict the sample further to children whose month of conception was during the pre-monsoon *Kharif-1* season (March to June), in which difficult climatic conditions, particularly in low-lying areas, make this period the one with the least productive potential (Das et al. 2020).[35] We find that when we interact salinity with the indicator *'cropland'*, the salinity effects on all child health outcomes are driven by children living in clusters with lower agricultural intensity caused by progressive salinization of lands. This means that lower income at the time of conception during this difficult season leads to poorer maternal nutrition and

[34] We also estimate equation (1) for each sub-sample for (i) clusters with below/above median agricultural activities, and (ii) clusters with below/above median biodiversity values (calculated as the sum of forest cover, cropland, shrub land, grass land, sparse vegetation, other bare areas, and water). The results all imply the presence of an agricultural mechanism.

[35] *Kharif-1* season is characterized by lower rainfall and higher temperature, affecting agro ecological conditions during the crop establishment stage. Major crops planted during this season include maize, soybean, jute, and *aus* rice, and irrigated conditions are beneficial.

fetal health (Molina and Sadarriaga 2017, Wilde et al. 2017). The effects of salinity indeed run through food insecurity and lower agricultural production.

To substantiate the above findings with more evidence that the agricultural channel is a plausible one working behind the salinity-child health nexus, we use the *History Database of the Global Environment – HYDE 3.2* (Goldewijk et al. 2017) to build indicator variables to proxy for the intensity of agricultural activities.[36] We use the available data from 2000 to 2017, and process the geospatial files for the gridded land use data (available at the 5 by 5 minutes resolution). We therefore obtain annual data for the total land used for grazing, for pasture, for the total rain-fed agricultural area, total rain-fed agricultural area devoted to the production of rice, and the total rain-fed agricultural area for other crops (except rice), all measured in squared km per grid cell.[37] We then consider the heterogeneous effect of ocean's salinity on child health outcomes, by the intensity of these agricultural activities. Figure 4 reports the coefficients on salinity exposure when different sub-samples are used based on indicator variables for each of these proxies. Children born in clusters experiencing lower agricultural activities are experiencing more pronounced negative health effects. We note also in the panel of coefficient plots of Figure 4, that the extent and intensity of rain-fed agricultural land devoted to rice production and to other crops clearly drive part of the effects of salinity on child health. Coefficients on salinity exposure for *"rice area"* and *"total rain-fed area"* are all statistically significant when the samples are restricted to children born in clusters experiencing below median agricultural activities in their year of birth. These additional findings lend support to our hypothesis pertaining to the agricultural mechanism.

7.0 Selection

We address the concerns that our estimates of the effect of *in utero* salinity exposure on early life health outcomes may be biased due to fetal selection that could induce a correlation between our variable of interest and the child's gender. *In utero* selection would imply that healthier fetuses have a higher likelihood of surviving, while weaker fetuses may die during pregnancy because of exposure to higher salinity levels. Existing empirical findings suggest that the long-term effects of early-life shocks involve boys' culling and girls' scarring (Catalano and Bruckner 2006, Liu et al.

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[36] Developed under the authority of the *Netherlands Environmental Assessment Agency,* the database provides gridded time series of population and land use from 10 000 B.C to 2000 A.D. The data is available for time intervals 100 years till 1700, 10 years till 2000, and in 1 year time step from 2000-2017.

[37] Note that this reduces the sample size since we cannot match the data for children born between 1994-1999, and in 2018.

2014), implying that *in utero* salinity exposure may affect the child's gender since male fetuses are more susceptible to shocks during pregnancy. The higher vulnerability of male fetuses can lead to excess male mortality in response to negative health shocks (Sanders and Stoecker, 2015).

While we cannot test directly for whether higher salinity levels affect the probability that the child dies *in utero* because of data limitations, we test in Table A7 for whether there are significant effects of salinity exposure on the probability that the child is male (without controlling for child and maternal characteristics).[38] In column (1), we find that our variable of interest has no significant effect on the probability that the child is male. In column (2), we consider the impact of the variation in *in utero* salinity levels while controlling for variation in salinity levels in the month of conception. In column (3), we consider only the average exposure for the 2-9 months during gestation, and in column (4), we include both salinity in the month of conception and in the 2-9 months during gestation.[39] And in column (5), we consider the non-linear specification by including quartiles of *in utero* salinity levels. Overall, the results in Table A7 suggest that variation in salinity during pregnancy does not predict the child's gender, and that fetal selection does not threaten the validity of our main findings.

We next consider the potential selection on parental characteristics. We demonstrate in Appendix Table A8 that maternal characteristics do not correlate with salinity exposure (the test for selection is motivated by Buckles and Hungerman (2013) and guided by the intuition provided in Wilde et al. (2017). We estimate equation (1) with pre-determined maternal characteristics as the dependent variables as a way of testing directly the statistical association between selection into parenthood and variation in salinity. The maternal characteristics considered are mother's education (6 and 12 years or less of education) in columns (1) and (2), height in column (3), a dummy variable that equals to one if she is currently working in column (4), age at the time of the interview, age at the time of delivery, and the age difference with the household's head (columns (5), (6), and (7) respectively). We do not identify any significant coefficient for our variable of interest in Table

[38] The DHS data does not allow us to test for the fetal selection hypothesis since there is no information on miscarriages and still births.
[39] Bratti et al. (2021) perform a similar analysis in their study of the impact of prenatal exposure to heat waves in Sub-Saharan Africa.

A8. This set of results means that selective fertility is an unlikely explanation for our main findings.[40]

To allay concerns related to selection arising from population sorting, we restrict the sample to include only children whose mothers have resided in the current place of interview for more than 7 years (the median number of years) in Panel A of Table A9.[41] Our estimates are of the same ballpark as those from Table 2, with salinity having a significantly negative impact on child health outcomes even when we restrict the analysis to women who have lived in the same area for an extended period of time. We then use the DHS information to construct a post-delivery control indicator variable that equals to one if the mother migrated to the current place of residence of the interview within the first 3 years following delivery. Panel B of Table A9 reports the results when we augment our regression with this control for post-delivery migration. In general, the results remain the same: exposure to higher salinity levels during pregnancy harms early-life development. The coefficients on the control for selective migration are insignificant throughout.

8.0 Conclusion

This paper sheds light on the effects of rising ocean salinity on health outcomes of children. We employ geo-referenced data on salinity, merged with child health outcomes from 6 waves of the Bangladesh Demographic Survey to empirically evaluate how variation in *in utero* salinity exposure affects children nutritional status in coastal Bangladesh. Our empirical strategy leverages a saturated fixed effects model that allows us to exploit the exogenous variation in salinity, while partialing out the effects of location-specific seasonality and local trends. Our results indicate that a one standard deviation increase in salinity during pregnancy decreases the HAZ score by approximately 6.6% relative to the mean, while increasing the prevalence of stunting and severe stunting. Similar effects are obtained for the other anthropometric measures. We underline the validity of our results with various robustness and specification checks.

Turning then to an analysis of the mechanisms, we find that these effects are more pronounced for girls, non-first born children, and children whose mothers were unemployed. We also show that higher salinity levels are associated with lower early childhood investments both in the prenatal

[40] Our analysis in Table A8 for selection also provides an additional placebo test for our main findings.

[41] Population sorting would be problematic if mothers setting in areas with lower salinity levels differ along socio-economic characteristics compared to mothers sorting in other areas.

and post-birth stages. The lack of compensating behaviors point to an income channel preventing women from having access to health care, and from using parental investments as an adaptation strategy. Using satellite information on agricultural land use, we find evidence that our results are explained by the intensity of agricultural activities-and thus by food insecurity and poorer nutritional intake.

These findings carry important implications for coastal communities in Bangladesh as climate change generates more environmental crises. A comprehensive assessment of the effects of rising salinity on health, and of the behavioral responses it triggers is essential to adopt adaptation measures to increase resilience to climate change, and to minimize the adverse effects on health, income, well-being, and other socio-economic outcomes.

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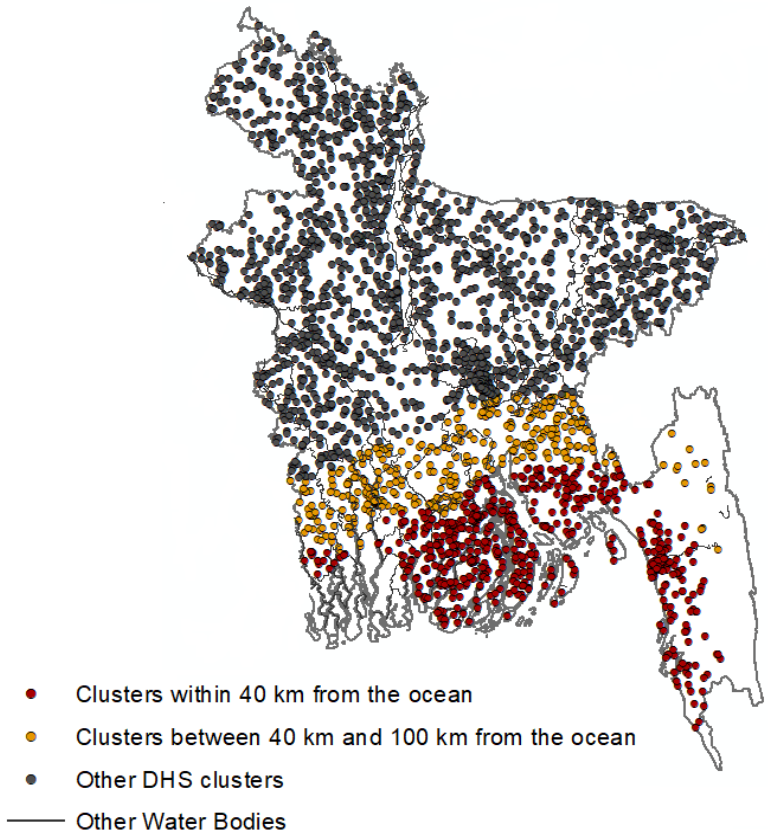
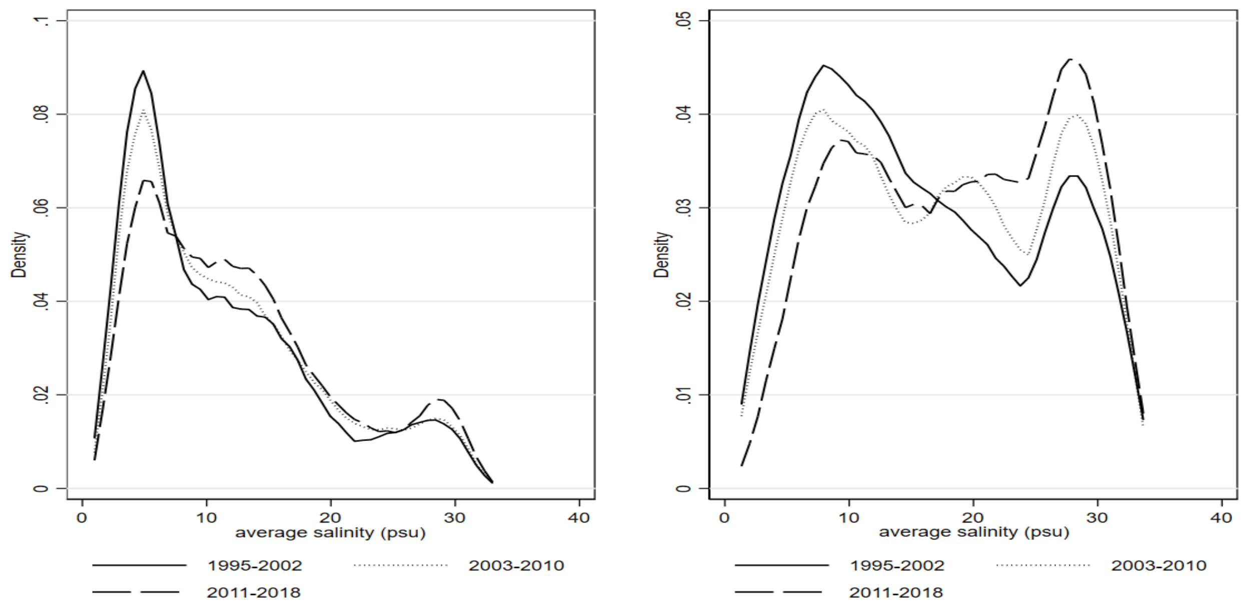
Figure 1: Identifying DHS Coastal Communities



Notes: Figure 1 shows the location of all DHS clusters in our sample. The red circles represent DHS coastal clusters that are within 40 km from the ocean. The yellow circles represent DHS coastal clusters that are between 40 km and 100 km from the ocean. Data citation: Wessel, P., and W. H. F. Smith, A Global Self-consistent, Hierarchical, High-resolution Shoreline Database, *J. Geophys. Res.*, *101*, 8741-8743, 1996

Figure 2: Kernel Densities of Salinity, 1995-2018

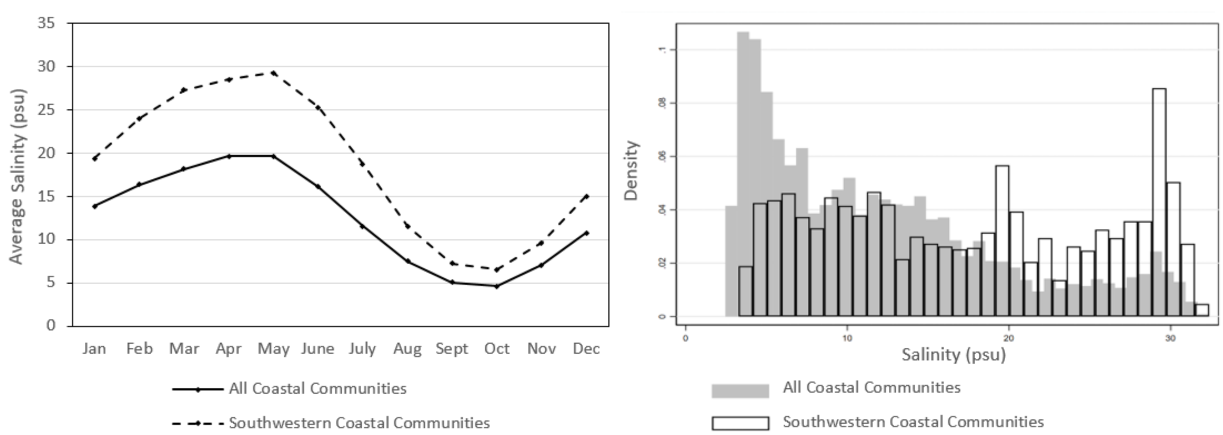
Panel A: All Coastal Communities **Panel B: Southwestern Coastal Communities**



Notes: Authors' calculations using the Copernicus Marine Environment Monitoring Service (CMEMS) for three periods. Panel A shows the kernel density for ocean's salinity for clusters within 100 km of the ocean (coastal communities). Panel B shows the kernel density for ocean's salinity for southwestern coastal clusters. To match the gridded salinity data to the cluster level, we use the IDW method as explained in the text.

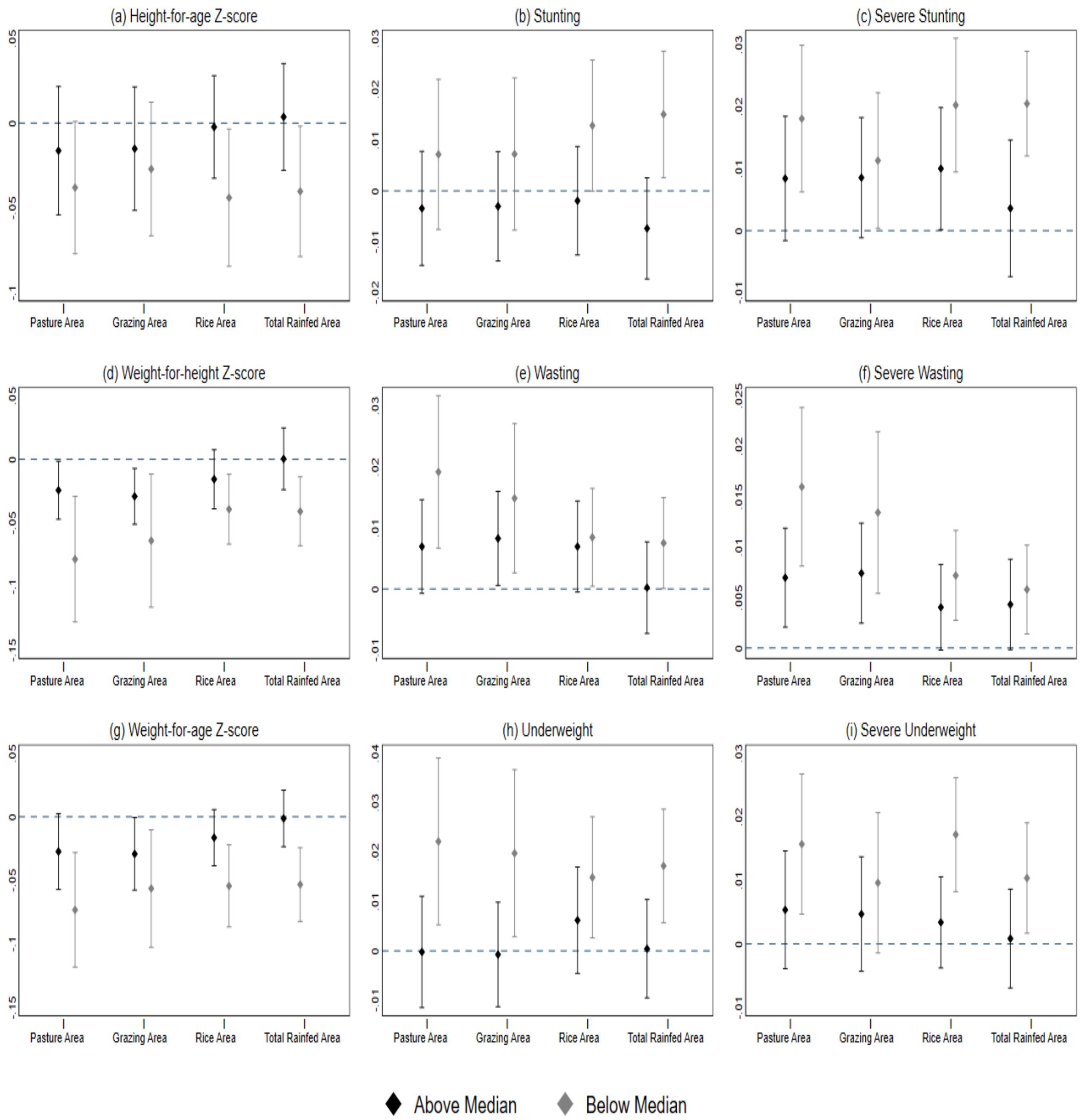
Figure 3: The Seasonality and Distribution of Salinity in Coastal Communities

Panel A: The Seasonality of Salinity (average over the months) **Panel B: The Distribution of Salinity**



Notes: Authors' calculations using the Copernicus Marine Environment Monitoring Service (CMEMS). Panel A shows the seasonality of salinity (this is the average salinity for each month over all the years). Panel B shows the distribution of salinity in the data. To match the gridded salinity data to the cluster level, we use the IDW method as explained in the text.

Figure 4: Heterogeneous Effects of Salinity Exposure on Child Health Outcomes, by Intensity of Agricultural Activities



Notes: The panel shows the heterogeneous effects of salinity while in utero on health outcomes by intensity of agricultural activities as proxied by indicator variables for below or above sample median values for pasture area, grazing area, rice, and rain-fed cultivated area. Estimates are from equation (1). Each coefficient is computed in separate regressions where the sample is restricted to the corresponding group. All regressions include child, mother, household, and weather controls, and ocean's pH levels used in the main regression analysis. The same set of spatial and temporal fixed effects are used. Please see Table 2 for details on dependent variables and controls. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. Confidence intervals are reported at 90% level.

Table 1: Summary Statistics

	Mean	Std. Deviation
	(1)	(2)
Panel A: health outcomes		
Height-for-age z-score (HAZ)	-1.804	1.417
Stunting (HAZ < 2 SD)	0.451	0.498
Severe stunting (HAZ < 3 SD)	0.190	0.392
Weight-for-age z-score (WAH)	-0.910	1.130
Wasting (WAH < 2 SD)	0.146	0.353
Severe wasting (WAH < 3 SD)	0.032	0.177
Weight-for-age z-score (WAZ)	-1.671	1.153
Underweight (WAZ < 2 SD)	0.390	0.488
Severe underweight (WAZ < 3 SD)	0.119	0.323
Panel B: ocean chemistry variables		
Seawater salinity (psu)	12.591	4.396
Ocean's pH level	8.199	0.045
Panel C: weather-related variables		
Minimum temperature (deg. celcius)	18.691	1.660
Maximum temperature (deg. celcius)	33.872	0.797
Rainfall (mm, logs)	5.360	0.402
Humidity (%)	81.274	2.466
Panel D: Child, mother, household controls		
Child's age (months)	29.307	17.298
Child is male	0.503	0.500
Child birth order	2.691	1.794
Mother's age at first birth	17.950	2.957
Mother's height	1509.765	53.874
Mother's education:		
Primary	0.303	0.460
Secondary	0.386	0.487
Tertiary	0.075	0.263
Head of household is male	0.871	0.335

Notes: The data sources include the BDHS 1999, 2004, 2007, 2011, 2014, and 2017, and the Copernicus Marine Environment Monitoring Service (CMEMS). The sample is restricted to coastal communities living within 40 km of the ocean.

Table 2: The Effects of Salinity Exposure During Pregnancy on Child Health Outcomes

	Dependent Variables:								
	HAZ	Stunted	Severely Stunted	WAH	Wasted	Severely Wasted	WAZ	Underweight	Severely Underweight
		(HAZ < 2 SD)	(HAZ < 3 SD)		(WAH < 2 SD)	(WAH < 3 SD)		(WAZ < 2 SD)	(WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Sample of DHS Coastal Clusters Within 40 km									
salinity exposure	-0.0259**	0.0075*	0.0128***	-0.0287**	0.0074**	0.0059***	-0.0360***	0.0110**	0.0058*
(in utero)	(0.0131)	(0.0044)	(0.0036)	(0.0112)	(0.0032)	(0.0020)	(0.0103)	(0.0044)	(0.0032)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
Mean of dependent variable	-1.8035	0.4514	0.1900	-0.9102	0.1456	0.0325	-1.6715	0.3896	0.1187
R-squared	0.3336	0.2831	0.2325	0.1734	0.1518	0.1626	0.2822	0.2275	0.1829
Panel B: Sample of DHS Coastal Clusters Within 100 km									
salinity exposure	-0.0080	0.0047	0.0093***	-0.0265***	0.0066**	0.0047***	-0.0241***	0.0069*	0.0050*
(in utero)	(0.0106)	(0.0037)	(0.0029)	(0.0096)	(0.0026)	(0.0016)	(0.0090)	(0.0036)	(0.0026)
Observations	12,576	12,576	12,576	12,576	12,576	12,576	12,576	12,576	12,576
Mean of dependent variable	-1.7266	0.4224	0.1673	-0.8365	0.1338	0.0286	-1.5739	0.3526	0.1018
R-squared	0.3069	0.2591	0.2180	0.1673	0.1315	0.1158	0.2730	0.2084	0.1649
Child, mother, household controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weather controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓	✓	✓	✓	✓
District, year of birth, month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth). The dependent variables in columns (1), (4), and (7) for height-for-age z-score, weight-for-height z-score, and for the weight-for-age z-score, respectively, are continuous. Dependent variables in columns (2), (5), and (8) are binary variables that equal to one if the child is stunted, wasted, and underweight, respectively, while in columns (3), (6), and (9), the binary variables equal to one if the child is severely stunted, severely wasted, and severely underweight, respectively. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. Panel A considers the sub-sample of DHS clusters that are within 40 km of the ocean while Panel B considers the sub-sample of DHS clusters that are within 100 km of the ocean. ***p<0.01, **p<0.05, *p<0.1

Table 3: The Heterogeneous Effects of Salinity (Based on Child and Maternal Characteristics) on Child Health Outcomes

	Dependent Variables:								
	HAZ	Stunted	Severely Stunted	WAH	Wasted	Severely Wasted	WAZ	Underweight	Severely Underweight
		(HAZ < 2 SD)	(HAZ < 3 SD)		(WAH < 2 SD)	(WAH < 3 SD)		(WAZ < 2 SD)	(WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A:			**Sub-Sample: Male Children Only**						
salinity exposure	-0.0035	0.0050	0.0013	-0.0410***	0.0057	0.0049**	-0.0289**	0.0062	0.0067*
(in utero)	(0.0160)	(0.0051)	(0.0044)	(0.0151)	(0.0053)	(0.0023)	(0.0133)	(0.0063)	(0.0039)
Observations	3,938	3,938	3,938	3,938	3,938	3,938	3,938	3,938	3,938
			Sub-Sample: Female Children Only						
salinity exposure	-0.0339*	0.0082	0.0223***	-0.0243	0.0119**	0.0084**	-0.0415***	0.0143**	0.0073
(in utero)	(0.0182)	(0.0065)	(0.0050)	(0.0153)	(0.0047)	(0.0033)	(0.0139)	(0.0062)	(0.0047)
Observations	3,910	3,910	3,910	3,910	3,910	3,910	3,910	3,910	3,910
Panel B:			**Sub-Sample: First Born Children Only**						
salinity exposure	-0.0276	0.0087	0.0022	-0.0172	0.0125*	0.0078**	-0.0319	0.0050	0.0021
(in utero)	(0.0253)	(0.0100)	(0.0060)	(0.0230)	(0.0073)	(0.0037)	(0.0198)	(0.0088)	(0.0057)
Observations	2,416	2,416	2,416	2,416	2,416	2,416	2,416	2,416	2,416
			Sub-Sample: Non-First Born Children						
salinity exposure	-0.0267*	0.0062	0.0150***	-0.0348***	0.0073*	0.0070***	-0.0409***	0.0134**	0.0098**
(in utero)	(0.0153)	(0.0052)	(0.0048)	(0.0132)	(0.0039)	(0.0024)	(0.0120)	(0.0057)	(0.0040)
Observations	5,437	5,437	5,437	5,437	5,437	5,437	5,437	5,437	5,437
Panel C:			**Sub-Sample: Mother's height (below median)**						
salinity exposure	-0.0292	0.0073	0.0132**	-0.0151	0.0093*	0.0052*	-0.0291*	0.0115	0.0020
(in utero)	(0.0182)	(0.0066)	(0.0052)	(0.0158)	(0.0052)	(0.0028)	(0.0150)	(0.0072)	(0.0054)
Observations	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950
			Sub-Sample: Mother's height (above median)						
salinity exposure	-0.0117	0.0059	0.0111**	-0.0504***	0.0059	0.0060**	-0.0414***	0.0092	0.0094**
(in utero)	(0.0181)	(0.0060)	(0.0046)	(0.0167)	(0.0042)	(0.0028)	(0.0149)	(0.0060)	(0.0040)
Observations	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900	3,900
Panel D:			**Sub-Sample: Working Mothers**						
salinity exposure	-0.0335	0.0212**	0.0118	-0.0220	0.0121	0.0093*	-0.0347	0.0158	-0.0010
(in utero)	(0.0297)	(0.0103)	(0.0089)	(0.0306)	(0.0084)	(0.0048)	(0.0253)	(0.0124)	(0.0085)
Observations	1,487	1,487	1,487	1,487	1,487	1,487	1,487	1,487	1,487
			Sub-Sample: Non-Working Mothers						
salinity exposure	-0.0295**	0.0052	0.0141***	-0.0231*	0.0063*	0.0047**	-0.0342***	0.0093**	0.0066*
(in utero)	(0.0146)	(0.0050)	(0.0038)	(0.0131)	(0.0036)	(0.0023)	(0.0120)	(0.0047)	(0.0038)
Observations	6,316	6,316	6,316	6,316	6,316	6,316	6,316	6,316	6,316

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth) for different sub-samples used in separate regressions. The dependent variables in columns (1), (4), and (7) for height-for-age z-score, weight-for-height z-score, and for the weight-for-age z-score, respectively, are continuous. Dependent variables in columns (2), (5), and (8) are binary variables that equal to one if the child is stunted, wasted, and underweight, respectively, while in columns (3), (6), and (9), the binary variables equal to one if the child is severely stunted, severely wasted, and severely underweight, respectively. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS, are weighted, and include the same set of fixed effects included in equation (1). Robust standard errors are clustered at the DHS cluster level. We consider DHS clusters within 40 km of the ocean. ***p<0.01, **p<0.05, *p<0.1

Table 4: The Heterogeneous Effects of Salinity (Based on Locational Characteristics) on Child Health Outcomes

	Dependent Variables:								
	HAZ	Stunted (HAZ < 2 SD)	Severely Stunted (HAZ < 3 SD)	WAH	Wasted (WAH < 2 SD)	Severely Wasted (WAH < 3 SD)	WAZ	Underweight (WAZ < 2 SD)	Severely Underweight (WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A				**Sub-Sample: Population Density (Below Median)**					
salinity exposure	-0.0296*	0.0047	0.0143**	-0.0275**	0.0021	0.0056*	-0.0377***	0.0044	0.0068
(in utero)	(0.0177)	(0.0062)	(0.0058)	(0.0137)	(0.0043)	(0.0029)	(0.0134)	(0.0058)	(0.0053)
Observations	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355
				Sub-Sample: Population Density (Above Median)					
salinity exposure	-0.0307	0.0109	0.0084	-0.0315	0.0071	0.0105**	-0.0380	0.0187*	0.0059
(in utero)	(0.0243)	(0.0101)	(0.0068)	(0.0274)	(0.0081)	(0.0049)	(0.0256)	(0.0108)	(0.0060)
Observations	3,372	3,372	3,372	3,372	3,372	3,372	3,372	3,372	3,372
Panel B				**Sub-Sample: Built-Up Areas (Below Median)**					
salinity exposure	-0.0373*	0.0078	0.0152**	-0.0303**	0.0095**	0.0083***	-0.0459***	0.0078	0.0083*
(in utero)	(0.0197)	(0.0062)	(0.0059)	(0.0152)	(0.0046)	(0.0032)	(0.0161)	(0.0061)	(0.0048)
Observations	3,327	3,327	3,327	3,327	3,327	3,327	3,327	3,327	3,327
				Sub-Sample: Built-Up Areas (Above Median)					
salinity exposure	0.0279	-0.0167*	-0.0005	0.0018	0.0035	0.0037	0.0207	-0.0154	0.0023
(in utero)	(0.0281)	(0.0092)	(0.0084)	(0.0339)	(0.0103)	(0.0044)	(0.0303)	(0.0115)	(0.0072)
Observations	3,370	3,370	3,370	3,370	3,370	3,370	3,370	3,370	3,370
Panel C				**Sub-Sample: Ocean's pH (Below Median)**					
salinity exposure	-0.0055	0.0037	0.0061	-0.0251*	0.0040	0.0029	-0.0214	0.0096	0.0005
(in utero)	(0.0186)	(0.0059)	(0.0042)	(0.0137)	(0.0047)	(0.0025)	(0.0135)	(0.0063)	(0.0037)
Observations	3,928	3,928	3,928	3,928	3,928	3,928	3,928	3,928	3,928
				Sub-Sample: Ocean's pH (Above Median)					
salinity exposure	-0.0404**	0.0150**	0.0252***	-0.0386**	0.0087**	0.0077***	-0.0526***	0.0160**	0.0164***
(in utero)	(0.0192)	(0.0062)	(0.0052)	(0.0179)	(0.0044)	(0.0030)	(0.0166)	(0.0062)	(0.0054)
Observations	3,922	3,922	3,922	3,922	3,922	3,922	3,922	3,922	3,922

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth) for different sub-samples used in separate regressions. The dependent variables in columns (1), (4), and (7) for height-for-age *z*-score, weight-for-height *z*-score, and for the weight-for-age *z*-score, respectively, are continuous. Dependent variables in columns (2), (5), and (8) are binary variables that equal to one if the child is stunted, wasted, and underweight, respectively, while in columns (3), (6), and (9), the binary variables equal to one if the child is severely stunted, severely wasted, and severely underweight, respectively. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS, are weighted, and include the same set of fixed effects included in equation (1). Robust standard errors are clustered at the DHS cluster level. We consider DHS clusters within 40 km of the ocean. ***p<0.01, **p<0.05, *p<0.1

Table 5: The Impact of Salinity on Parental Investments, Health-Seeking Behavior and Prenatal Care

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Panel A: Sample of DHS Coastal Clusters Within 40 km						
	Early Investments in Child Health: Vaccination Received						
	Polio 1	Polio 2	BCG	DPT 1	DPT 2	Measles	Tetanus
salinity exposure	-0.0062*	-0.0106**	-0.0045	-0.0046	-0.0112**	-0.0114**	-0.0122*
(in utero)	(0.0033)	(0.0047)	(0.0036)	(0.0036)	(0.0049)	(0.0055)	(0.0067)
Observations	7,423	7,402	7,421	7,421	7,421	7,397	4,209
R-squared	0.3151	0.3766	0.2688	0.3153	0.3711	0.5065	0.2616
	Panel B: Sample of DHS Coastal Clusters Within 40 km						
	Prenatal Care and At Birth Investments						
	No. of antenatal vistits	Received iron tablet	Prenatal care: Doctor	Nurse	Assistance at birth: Doctor	Nurse	Delivery: at home
salinity exposure	-0.1405***	-0.0185***	-0.0177***	-0.0063**	-0.0078**	-0.0127***	0.0172***
(in utero)	(0.0313)	(0.0071)	(0.0052)	(0.0031)	(0.0033)	(0.0043)	(0.0046)
Observations	5,868	3,679	5,867	5,867	6,858	6,858	7,933
R-squared	0.4143	0.3473	0.3985	0.1790	0.3277	0.3628	0.4155
Child, mother, household controls	✓	✓	✓	✓	✓	✓	✓
Weather controls	✓	✓	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓	✓	✓
District, year of birth, month of birth FE	✓	✓	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓	✓	✓

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth). The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. Panel A considers the sub-sample of DHS clusters that are within 40 km of the ocean, and the dependent variables are coded as 1 if the child has received the type of vaccination presented in each column. In Panel B, we consider the same sample of coastal communities, and the dependent variable is continuous in column (1) for the number of antenatal visits. The other outcome variables in columns (2) to (7) are binary variables that equal to one if the mother received iron tablet during pregnancy, prenatal care, assistance at birth, and if delivery happened at home, respectively . ***p<0.01, **p<0.05, *p<0.1

Table 6: The Effects of Salinity Exposure During Pregnancy on Child Health Outcomes (Conditioning on Agricultural Activities)

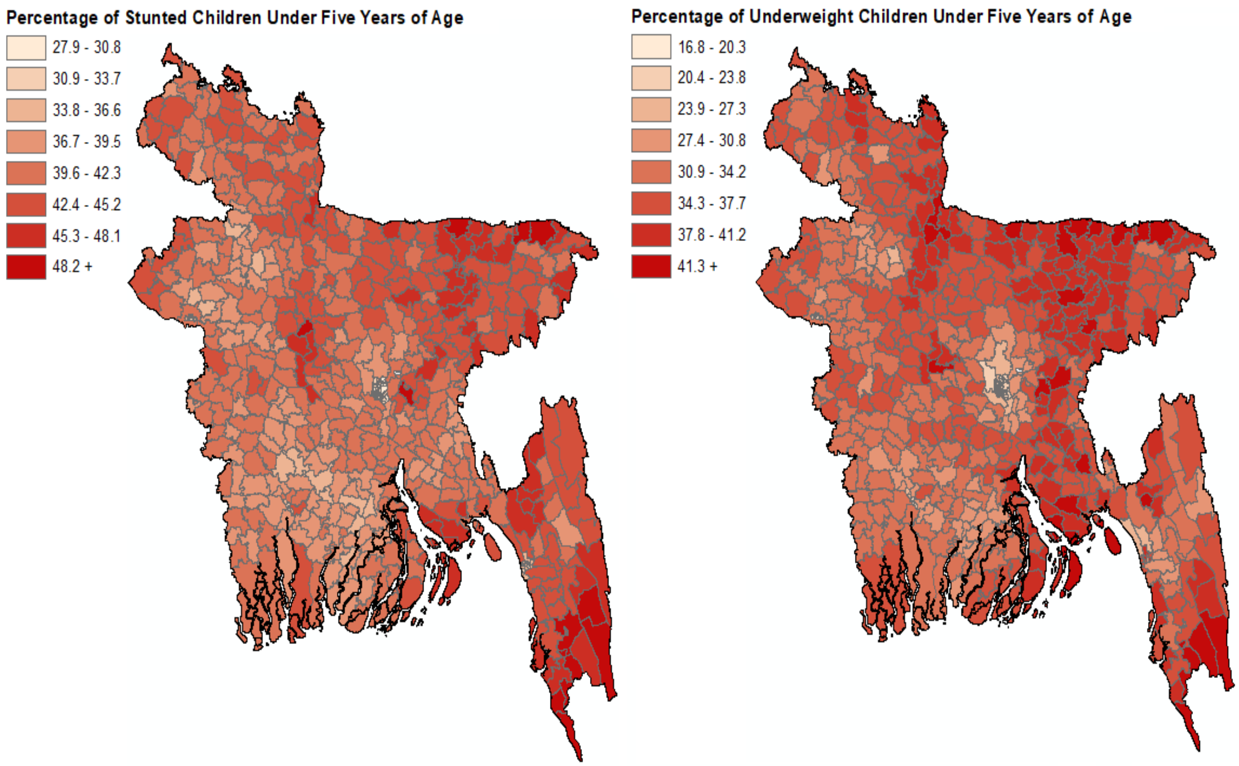
	Dependent Variables:								
	HAZ	Stunted (HAZ < 2 SD)	Severely Stunted (HAZ < 3 SD)	WAH	Wasted (WAH < 2 SD)	Severely Wasted (WAH < 3 SD)	WAZ	Underweight (WAZ < 2 SD)	Severely Underweight (WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Sample of DHS Coastal Clusters Within 40 km (controlling for cropland)									
salinity exposure	-0.0229*	0.0064	0.0098***	-0.0245**	0.0068**	0.0055***	-0.0313***	0.0083*	0.0029
(in utero)	(0.0129)	(0.0045)	(0.0033)	(0.0121)	(0.0033)	(0.0020)	(0.0102)	(0.0044)	(0.0031)
cropland (indicator variable)	-0.0506	0.0196	0.0501**	-0.0704	0.0107	0.0074	-0.0788	0.0460**	0.0492***
	(0.0660)	(0.0237)	(0.0196)	(0.0476)	(0.0160)	(0.0091)	(0.0499)	(0.0215)	(0.0154)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
Mean of dependent variable	-1.8035	0.4514	0.1900	-0.9102	0.1456	0.0325	-1.6715	0.3896	0.1187
R-squared	0.3337	0.2832	0.2336	0.1737	0.1519	0.1627	0.2825	0.2281	0.1844
Panel B: Sample of DHS Coastal Clusters Within 40 km (controlling for cropland, forest, tree cover flooded with saline water)									
salinity exposure	-0.0239*	0.0064	0.0100***	-0.0237**	0.0066**	0.0054***	-0.0314***	0.0082*	0.0027
(in utero)	(0.0126)	(0.0045)	(0.0034)	(0.0119)	(0.0033)	(0.0019)	(0.0101)	(0.0044)	(0.0031)
cropland (indicator variable)	0.0145	0.0096	0.0316*	-0.0703	0.0123	0.0082	-0.0408	0.0370*	0.0399***
	(0.0647)	(0.0242)	(0.0182)	(0.0524)	(0.0159)	(0.0083)	(0.0519)	(0.0220)	(0.0149)
forest (indicator variable)	-0.0842*	0.0072	0.0165	0.0465	-0.0107	-0.0041	-0.0196	-0.0008	-0.0065
	(0.0493)	(0.0185)	(0.0145)	(0.0405)	(0.0127)	(0.0075)	(0.0442)	(0.0186)	(0.0122)
trees flooded with saline water	-0.1441***	0.0292	0.0503***	-0.0590	0.0075	0.0023	-0.1215**	0.0356*	0.0441***
(indicator variable)	(0.0535)	(0.0194)	(0.0162)	(0.0533)	(0.0133)	(0.0070)	(0.0479)	(0.0206)	(0.0128)
Child, mother, household controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weather controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓	✓	✓	✓	✓
District, year of birth, month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth). The dependent variables in columns (1), (4), and (7) for height-for-age *z*-score, weight-for-height *z*-score, and for the weight-for-age *z*-score, respectively, are continuous. Dependent variables in columns (2), (5), and (8) are binary variables that equal to one if the child is stunted, wasted, and underweight, respectively, while in columns (3), (6), and (9), the binary variables equal to one if the child is severely stunted, severely wasted, and severely underweight, respectively. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. We consider the sub-sample of DHS clusters that are within 40 km of the ocean. ***p<0.01, **p<0.05, *p<0.1

Appendix

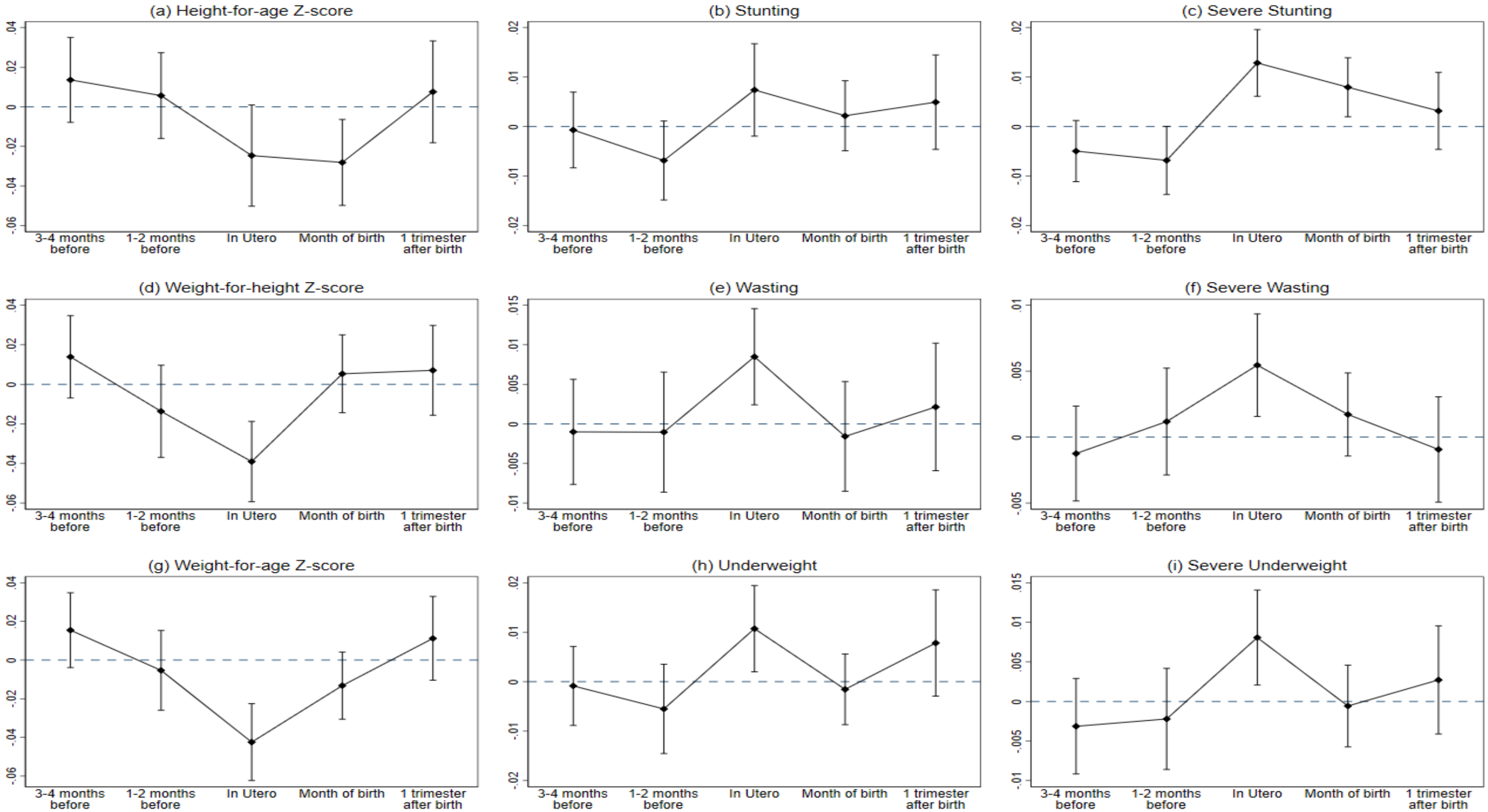
Figure A1: The Nutritional Status of Children in Bangladesh

Panel A **Panel B**



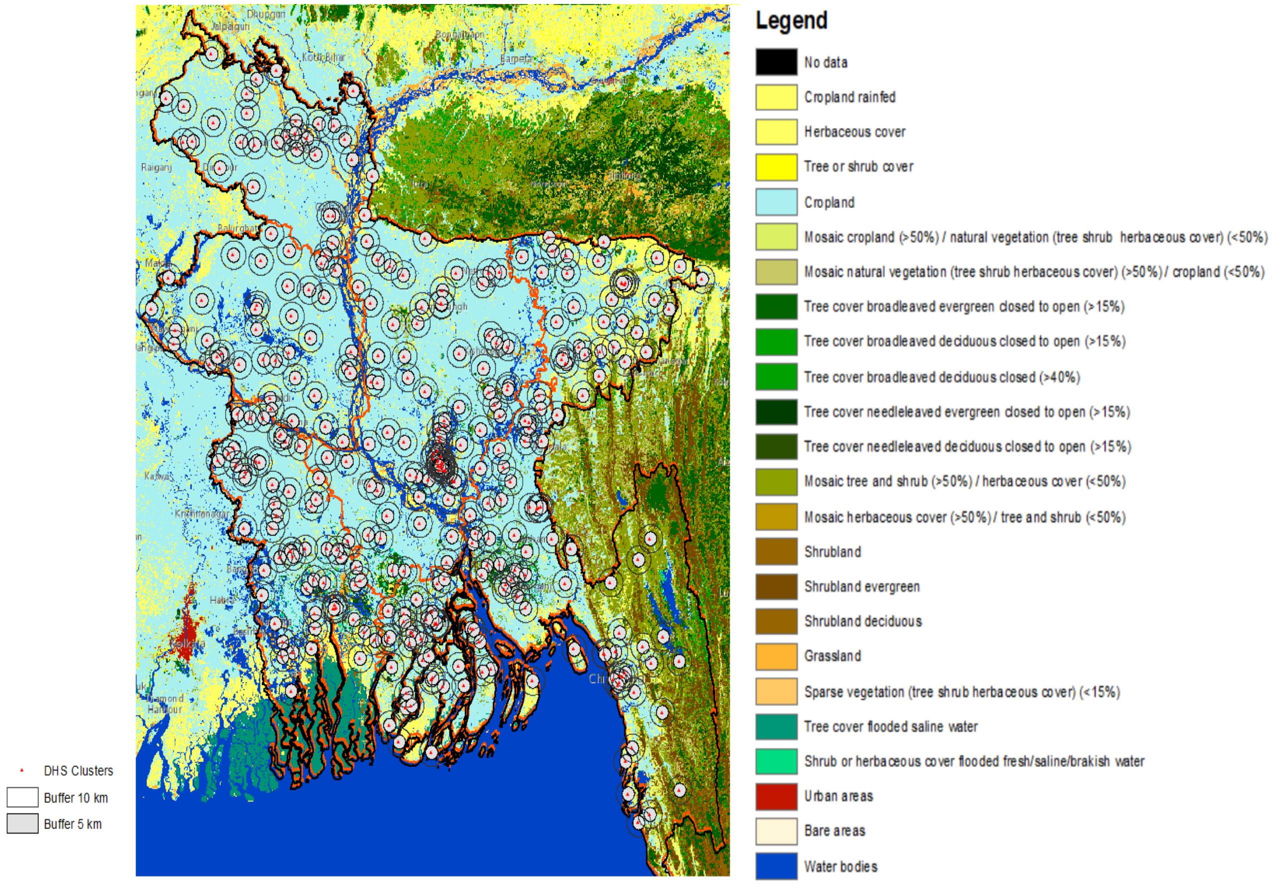
Notes: Panel A shows the percentage of stunted children under five years of age at the *upazila* (sub-district) level in 2012 in Bangladesh, while Panel B shows the percentage of underweight children under five years of age at the *upazila* (sub-district) level in 2012. The data is available from the Food and Agriculture Organization (FAO), and uses the 2012 Undernutrition Maps of Bangladesh.

Appendix Figure A2: The Effects of Salinity During Pregnancy on Child Health Outcomes (Controlling for Salinity Levels Before Conception and After Birth)



Notes: The data shows the coefficients of salinity exposure (at different times in the baseline specification). We augment equation (1) with controls for the average salinity levels 1-2 months before conception, 3-4 months before conception, in the month of birth, and one trimester after birth. The sample is restricted to DHS clusters that are within 40 km from the ocean. We use the same set of control, spatial and temporal fixed effects as reported in Table 2. Confidence intervals are reported at 90% level. The timing of exposure is shown on the horizontal axis, and corresponding point estimates are shown on the vertical axis.

Appendix Figure A3: Land-Cover Classifications in 1993 and DHS Clusters of 1999



Notes: This shows the land cover map for 1993, and the location of the DHS clusters as of 1999. We also show buffers of 5 km and 10 km drawn around each cluster to obtain an estimate of land cover use. Data citation: Defourny, P., Lamarche, C., Bontemps, S., De Maet, T., Van Bogaert, E., Moreau, I., Brockmann, C., Boettcher, M., Kirches, G., Wevers, J., Santoro, M., Ramoino, F., & Arino, O. (2017). Land Cover Climate Change Initiative - Product User Guide v2. Issue 2

Table A1: The Effects of Salinity Exposure During Pregnancy on Child Health Outcomes (Using Alternative Measures of Exposure and Additional Controls)

	Dependent Variables:								
	HAZ	Stunted	Severely Stunted	WAH	Wasted	Severely Wasted	WAZ	Underweight	Severely Underweight
		(HAZ < 2 SD)	(HAZ < 3 SD)		(WAH < 2 SD)	(WAH < 3 SD)		(WAZ < 2 SD)	(WAZ < 3 SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A:	**Sample of DHS Coastal Clusters Within 40 km**								
accumulated salinity levels (logs)	-0.3354*	0.0926	0.1730***	-0.3463**	0.0956**	0.0930***	-0.4508***	0.1407**	0.0853**
(past 9 months)	(0.1729)	(0.0585)	(0.0480)	(0.1442)	(0.0419)	(0.0259)	(0.1384)	(0.0563)	(0.0421)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3337	0.2831	0.2327	0.1733	0.1518	0.1636	0.2821	0.2275	0.1830
Panel B:	**Sample of DHS Coastal Clusters Within 40 km**								
salinity exposure	-0.0265**	0.0077*	0.0127***	-0.0277**	0.0068**	0.0056***	-0.0356***	0.0108**	0.0054
(in utero)	(0.0134)	(0.0045)	(0.0036)	(0.0111)	(0.0032)	(0.0020)	(0.0105)	(0.0045)	(0.0033)
number of months with above	0.0171	-0.0046	0.0020	-0.0287	0.0169**	0.0075	-0.0098	0.0054	0.0119
cluster mean	(0.0365)	(0.0125)	(0.0097)	(0.0338)	(0.0085)	(0.0051)	(0.0315)	(0.0126)	(0.0078)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3337	0.2831	0.2325	0.1736	0.1524	0.1630	0.2822	0.2275	0.1832
Panel C:	**Sample of DHS Coastal Clusters Within 40 km**								
standard deviation of salinity	-0.0318	0.0061	0.0167***	-0.0289*	0.0049	0.0098***	-0.0400**	0.0128*	0.0117**
(for the 9 months before birth)	(0.0217)	(0.0071)	(0.0058)	(0.0168)	(0.0052)	(0.0033)	(0.0170)	(0.0072)	(0.0049)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3334	0.2828	0.2319	0.1727	0.1512	0.1628	0.2813	0.2271	0.1832
Panel D:	**Sample of DHS Coastal Clusters Within 40 km (excluding southwestern districts)**								
salinity exposure	-0.0260*	0.0069	0.0126***	-0.0250**	0.0063**	0.0070***	-0.0337***	0.0117**	0.0069**
(in utero)	(0.0143)	(0.0047)	(0.0039)	(0.0103)	(0.0031)	(0.0022)	(0.0110)	(0.0046)	(0.0033)
Observations	7,164	7,164	7,164	7,164	7,164	7,164	7,164	7,164	7,164
R-squared	0.3412	0.2864	0.2396	0.1779	0.1570	0.1742	0.2930	0.2312	0.1933
Panel E:	**Sample of DHS Coastal Clusters Within 40 km**								
salinity exposure	-0.0248*	0.0068	0.0120***	-0.0304***	0.0080**	0.0062***	-0.0363***	0.0120***	0.0060*
(in utero - assume 10 months)	(0.0136)	(0.0047)	(0.0038)	(0.0112)	(0.0032)	(0.0021)	(0.0106)	(0.0045)	(0.0033)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3338	0.2835	0.2326	0.1735	0.1518	0.1627	0.2822	0.2275	0.1825

Notes: All regressions include child, mother, household controls, weather controls, and pH used in the main regression analysis. The same set of spatial and temporal fixed effects are used. Please see Table 2 for details on dependent variables and controls. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. ***p<0.01, **p<0.05, *p<0.1.

Table A2: The Effects of Salinity Exposure During Pregnancy on Child Health Outcomes (Controlling for Ocean-Chemistry Variables)

	Dependent Variables:								
	HAZ	Stunted	Severely Stunted	WAH	Wasted	Severely Wasted	WAZ	Underweight	Severely Underweight
		(HAZ < 2 SD)	(HAZ < 3 SD)		(WAH < 2 SD)	(WAH < 3 SD)		(WAZ < 2 SD)	(WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sample of DHS Coastal Clusters Within 40 km									
Controlling for Other Ocean-Chemistry Variables									
salinity exposure	-0.0228*	0.0071	0.0127***	-0.0296**	0.0086**	0.0063***	-0.0350***	0.0103**	0.0057*
(in utero)	(0.0136)	(0.0047)	(0.0036)	(0.0120)	(0.0033)	(0.0021)	(0.0105)	(0.0045)	(0.0033)
Child, mother, household controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weather controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓	✓	✓	✓	✓
District, year of birth, month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth). The dependent variables in columns (1), (4), and (7) for height-for-age z-score, weight-for-height z-score, and for the weight-for-age z-score, respectively, are continuous. Dependent variables in columns (2), (5), and (8) are binary variables that equal to one if the child is stunted, wasted, and underweight, respectively, while in columns (3), (6), and (9), the binary variables equal to one if the child is severely stunted, severely wasted, and severely underweight, respectively. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. We consider the sub-sample of DHS clusters that are within 40 km of the ocean. The additional ocean-chemistry variables are: sea temperature, sea surface height, east velocity, and north velocity. ***p<0.01, **p<0.05, *p<0.1

Table A3: The Effects of Salinity Exposure During Pregnancy on Child Health Outcomes (Using Non-Linear Specifications)

	Dependent Variables:								
	HAZ	Stunted (HAZ < 2 SD)	Severely Stunted (HAZ < 3 SD)	WAH	Wasted (WAH < 2 SD)	Severely Wasted (WAH < 3 SD)	WAZ	Underweight (WAZ < 2 SD)	Severely Underweight (WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Sample of DHS Coastal Clusters Within 40 km (Using below/above median sample value of salinity)									
salinity exposure	-0.1332**	0.0270	0.0328*	-0.1430***	0.0341**	0.0388***	-0.1947***	0.0648***	0.0408***
(in utero) above median	(0.0663)	(0.0224)	(0.0186)	(0.0550)	(0.0152)	(0.0122)	(0.0538)	(0.0206)	(0.0157)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3337	0.2829	0.2311	0.1734	0.1517	0.1639	0.2824	0.2278	0.1834
Panel B: Sample of DHS Coastal Clusters Within 40 km (Using quartiles of salinity)									
salinity exposure	-0.0294	0.0128	0.0454**	-0.0139	0.0144	0.0235**	-0.0166	0.0008	0.0120
(in utero) second quartile	(0.0623)	(0.0249)	(0.0190)	(0.0667)	(0.0204)	(0.0104)	(0.0582)	(0.0245)	(0.0167)
salinity exposure	-0.1579*	0.0358	0.0672***	-0.1497**	0.0446*	0.0586***	-0.2055***	0.0634**	0.0511**
(in utero) third quartile	(0.0871)	(0.0309)	(0.0251)	(0.0732)	(0.0249)	(0.0152)	(0.0740)	(0.0286)	(0.0226)
salinity exposure	-0.1571	0.0599	0.1133***	-0.2133**	0.0653**	0.0584***	-0.2451***	0.0892**	0.0483
(in utero) fourth quartile	(0.1116)	(0.0403)	(0.0302)	(0.0973)	(0.0298)	(0.0174)	(0.0933)	(0.0396)	(0.0298)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3337	0.2831	0.2324	0.1735	0.1519	0.1649	0.2824	0.2279	0.1834
Panel C: Sample of DHS Coastal Clusters Within 40 km (excluding southwestern districts) (Using quartiles of salinity and excluding southwestern districts)									
salinity exposure	-0.0023	-0.0081	0.0210	-0.0791	0.0210	0.0271**	-0.0448	0.0173	0.0059
(in utero) second quartile	(0.0693)	(0.0260)	(0.0203)	(0.0664)	(0.0211)	(0.0109)	(0.0614)	(0.0249)	(0.0184)
salinity exposure	-0.1057	0.0083	0.0567**	-0.1557**	0.0382*	0.0499***	-0.1763**	0.0602**	0.0402**
(in utero) third quartile	(0.0816)	(0.0288)	(0.0251)	(0.0682)	(0.0231)	(0.0125)	(0.0683)	(0.0272)	(0.0197)
salinity exposure	-0.2074*	0.0476	0.0743**	-0.2363***	0.0510*	0.0559***	-0.2999***	0.1075***	0.0670**
(in utero) fourth quartile	(0.1072)	(0.0352)	(0.0312)	(0.0895)	(0.0273)	(0.0176)	(0.0904)	(0.0356)	(0.0264)
Observations	7,164	7,164	7,164	7,164	7,164	7,164	7,164	7,164	7,164
R-squared	0.3414	0.2866	0.2390	0.1782	0.1570	0.1749	0.2937	0.2317	0.1940

Notes: All regressions include child, mother, household controls, weather controls, and pH used in the main regression analysis. The same set of spatial and temporal fixed effects are used too. Please see Table 2 for details on dependent variables and controls. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. ***p<0.01, **p<0.05, *p<0.1

Table A4: The Effects of Salinity Exposure During Pregnancy on Child Health Outcomes (By Trimester of Gestation)

	Dependent Variables:								
	HAZ	Stunted	Severely Stunted	WAH	Wasted	Severely Wasted	WAZ	Underweight	Severely Underweight
		(HAZ < 2 SD)	(HAZ < 3 SD)		(WAH < 2 SD)	(WAH < 3 SD)		(WAZ < 2 SD)	(WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Sample of DHS Coastal Clusters Within 40 km								
salinity exposure	0.0089	-0.0039	-0.0005	-0.0221**	0.0052*	0.0026	-0.0081	0.0032	0.0014
(in utero) 1st trimester	(0.0105)	(0.0040)	(0.0025)	(0.0095)	(0.0029)	(0.0018)	(0.0087)	(0.0038)	(0.0030)
salinity exposure	-0.0248**	0.0081**	0.0101***	-0.0032	-0.0011	-0.0006	-0.0188**	0.0055	0.0035
(in utero) 2nd trimester	(0.0109)	(0.0038)	(0.0028)	(0.0084)	(0.0031)	(0.0014)	(0.0077)	(0.0036)	(0.0025)
salinity exposure	-0.0081	0.0026	0.0025	-0.0039	0.0038	0.0043***	-0.0082	0.0020	0.0008
(in utero) 3rd trimester	(0.0098)	(0.0032)	(0.0025)	(0.0098)	(0.0031)	(0.0014)	(0.0086)	(0.0037)	(0.0025)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3341	0.2836	0.2330	0.1738	0.1521	0.1632	0.2822	0.2275	0.1829

Notes: All regressions include child, mother, household controls, weather controls, and pH used in the main regression analysis. The same set of spatial and temporal fixed effects are used. Please see Table 2 for details on dependent variables and controls. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. ***p<0.01, **p<0.05, *p<0.1.

Table A5: The Impact of Salinity on Parental Health Investments, Health-Seeking Behavior, and Prenatal Care (by Gender and Birth Order)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Panel A: Sample of DHS Coastal Clusters Within 40 km				
			Early Investments in Child Health: Vaccination Received				
	Polio 1	Polio 2	BCG	DPT 1	DPT 2	Measles	Tetanus
			Sub-Sample: Male Children Only				
salinity exposure	-0.0065*	-0.0122**	-0.0039	-0.0037	-0.0110**	-0.0148***	-0.0066
(in utero)	(0.0039)	(0.0050)	(0.0043)	(0.0043)	(0.0049)	(0.0056)	(0.0095)
			Sub-Sample: Female Children Only				
salinity exposure	-0.0062	-0.0104*	-0.0071	-0.0069	-0.0115*	-0.0067	-0.0201**
(in utero)	(0.0040)	(0.0060)	(0.0046)	(0.0044)	(0.0064)	(0.0072)	(0.0080)
			Sub-Sample: First Born Children Only				
salinity exposure	-0.0077*	-0.0148**	-0.0089**	-0.0084*	-0.0162**	-0.0090	-0.0038
(in utero)	(0.0046)	(0.0069)	(0.0043)	(0.0048)	(0.0070)	(0.0072)	(0.0122)
			Sub-Sample: Non-First Born Children Only				
salinity exposure	-0.0061	-0.0087*	-0.0035	-0.0039	-0.0100*	-0.0140**	-0.0138*
(in utero)	(0.0041)	(0.0052)	(0.0043)	(0.0043)	(0.0055)	(0.0062)	(0.0072)
			Panel B: Sample of DHS Coastal Clusters Within 40 km				
			Prenatal Care and At Birth Investments				
	No. of antenatal		Prenatal care:		Assistance at birth:		
	vistits	Received iron tablet	Doctor	Nurse	Doctor	Nurse	Delivery: at home
			Sub-Sample: Male Children Only				
salinity exposure	-0.1419***	-0.0126	-0.0194***	-0.0029	-0.0087*	-0.0158**	0.0198***
(in utero)	(0.0400)	(0.0105)	(0.0074)	(0.0049)	(0.0049)	(0.0061)	(0.0063)
			Sub-Sample: Female Children Only				
salinity exposure	-0.1548***	-0.0268***	-0.0181***	-0.0098**	-0.0057	-0.0081	0.0132**
(in utero)	(0.0357)	(0.0101)	(0.0067)	(0.0044)	(0.0054)	(0.0062)	(0.0062)
			Sub-Sample: First Born Children Only				
salinity exposure	-0.1906***	-0.0016	-0.0128	-0.0055	0.0010	-0.0111	0.0235***
(in utero)	(0.0536)	(0.0149)	(0.0102)	(0.0067)	(0.0069)	(0.0094)	(0.0086)
			Sub-Sample: Non-First Born Children Only				
salinity exposure	-0.1403***	-0.0218***	-0.0207***	-0.0063*	-0.0086**	-0.0124***	0.0171***
(in utero)	(0.0348)	(0.0074)	(0.0061)	(0.0033)	(0.0036)	(0.0042)	(0.0047)

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth) for different sub-samples used in separate regressions. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS, are weighted, and include the same set of fixed effects included in equation (1). Robust standard errors are clustered at the DHS cluster level. Panel A considers the sub-sample of DHS clusters that are within 40 km of the ocean, and the dependent variables are coded as 1 if the child has received the type of vaccination presented in each column. In Panel B, we consider the same sample of coastal communities, and the dependent variable is continuous in column (1) for the number of antenatal visits. The other outcome variables in columns (2) to (7) are binary variables that equal to one if the mother received iron tablet during pregnancy, prenatal care, assistance at birth, and if delivery happened at home, respectively. ***p<0.01, **p<0.05, *p<0.1

Table A6: The Heterogeneous Effects (By Agricultural Activities) of Salinity Exposure During Pregnancy

	Dependent Variables:								
	HAZ	Stunted	Severely Stunted	WAH	Wasted	Severely Wasted	WAZ	Underweight	Severely Underweight
		(HAZ < 2 SD)	(HAZ < 3 SD)		(WAH < 2 SD)	(WAH < 3 SD)		(WAZ < 2 SD)	(WAZ < 3 SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Sample of DHS Coastal Clusters Within 40 km									
salinity exposure	-0.0207	0.0039	0.0096**	-0.0122	0.0016	0.0056***	-0.0208*	0.0020	0.0020
(in utero)	(0.0147)	(0.0052)	(0.0042)	(0.0129)	(0.0036)	(0.0019)	(0.0111)	(0.0049)	(0.0032)
cropland (indicator variable)	0.0672	-0.0317	0.0252	0.1195	-0.0702*	0.0117	0.1339	-0.0654	0.0289
	(0.1450)	(0.0571)	(0.0449)	(0.1231)	(0.0410)	(0.0183)	(0.1188)	(0.0546)	(0.0370)
salinity x cropland	-0.0046	0.0036	0.0006	-0.0166*	0.0072**	-0.0003	-0.0152*	0.0089**	0.0010
	(0.0112)	(0.0042)	(0.0034)	(0.0097)	(0.0032)	(0.0013)	(0.0088)	(0.0041)	(0.0025)
Observations	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933	7,933
R-squared	0.3352	0.2836	0.2354	0.1743	0.1526	0.1628	0.2838	0.2290	0.1861
Panel B: Sample of DHS Coastal Clusters Within 40 km (Month of Conception during Kharif-1 Season)									
salinity exposure	0.0129	-0.0000	-0.0003	0.0111	-0.0095	0.0032	0.0120	-0.0076	-0.0080
(in utero)	(0.0277)	(0.0110)	(0.0082)	(0.0279)	(0.0077)	(0.0042)	(0.0241)	(0.0099)	(0.0071)
cropland (indicator variable)	0.3856*	-0.1115	-0.0520	0.6606***	-0.1596**	-0.0058	0.6604***	-0.2948***	-0.0995
	(0.2269)	(0.0971)	(0.0788)	(0.2100)	(0.0668)	(0.0338)	(0.1881)	(0.0889)	(0.0659)
salinity x cropland	-0.0423**	0.0171*	0.0075	-0.0638***	0.0144**	0.0005	-0.0652***	0.0309***	0.0115**
	(0.0212)	(0.0087)	(0.0070)	(0.0212)	(0.0063)	(0.0034)	(0.0171)	(0.0082)	(0.0056)
Observations	2,343	2,343	2,343	2,343	2,343	2,343	2,343	2,343	2,343
R-squared	0.4013	0.3538	0.3123	0.2355	0.2252	0.2005	0.3649	0.3222	0.2733
Child, mother, household controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weather controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓	✓	✓	✓	✓
District, year of birth, month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth). The dependent variables in columns (1), (4), and (7) for height-for-age z-score, weight-for-height z-score, and for the weight-for-age z-score, respectively, are continuous. Dependent variables in columns (2), (5), and (8) are binary variables that equal to one if the child is stunted, wasted, and underweight, respectively, while in columns (3), (6), and (9), the binary variables equal to one if the child is severely stunted, severely wasted, and severely underweight, respectively. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels, and for the two indicator variables used in Table 6 (forest and trees flooded with saline water) All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. We consider the sub-sample of DHS clusters that are within 40 km of the ocean. ***p<0.01, **p<0.05, *p<0.1

Table A7: The Effects of Salinity Exposure on the Child's gender

	Dependent Variable: probability that the child is male				
	(1)	(2)	(3)	(4)	(5)
	Sample of DHS Coastal Clusters Within 40 km				
salinity exposure	-0.0019	-0.0034			
(in utero)	(0.0040)	(0.0056)			
salinity exposure		0.0018		0.0014	
(in month of conception)		(0.0038)		(0.0034)	
salinity exposure			-0.0021	-0.0030	
(2-9 months during gestation)			(0.0040)	(0.0050)	
salinity exposure					0.0178
(in utero) second quartile					(0.0278)
salinity exposure					-0.0016
(in utero) third quartile					(0.0302)
salinity exposure					-0.0282
(in utero) fourth quartile					(0.0376)
Observations	7,978	7,978	7,978	7,978	7,978
R-squared	0.1297	0.1298	0.1297	0.1298	0.1300
Child, mother, household controls	×	×	×	×	×
Weather controls	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓
District, year of birth, month of birth FE	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓

Notes: This table shows the impact of salinity on the probability that the child is male. The dependent variable is a dummy variable that equals to one if the child is male. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. We sub-sample of DHS clusters that are within 40 km of the ocean.***p<0.01, **p<0.05, *p<0.1

Table A8: The Effects of Salinity Exposure on Mother's Characteristics

	Dependent Variables:						
	mother's education		mother's	mother	mother's	mother 's age	age difference
	<= 6 years	<= 12 years	height	employed	current age	at delivery	with head
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Sample of DHS Coastal Clusters Within 40 km						
salinity exposure	0.0008	0.0014	1.0285	-0.0023	0.0801	0.0572	0.0279
(in utero)	(0.0067)	(0.0016)	(0.6367)	(0.0056)	(0.0521)	(0.0485)	(0.1379)
Observations	7,978	7,978	7,933	7,978	7,978	7,978	7,978
R-squared	0.1441	0.1000	0.1263	0.2113	0.1480	0.1295	0.1408
Child, mother, household controls	×	×	×	×	×	×	×
Weather controls	✓	✓	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓	✓	✓
District, year of birth, month of birth FE	✓	✓	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓	✓	✓

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth) on mother's characteristics. The dependent variables in columns (1) and (2) are binary variables that equal to one if the mother has 6 and 12 years or less of education, respectively. The dependent variables in columns (3), (5), (6), and (7) are continuous. The dependent variable in column (4) is a binary variable that equals to one if the mother is currently working. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. We the sub-sample of DHS clusters that are within 40 km of the ocean. ***p<0.01, **p<0.05, *p<0.1

Table A9: The Effects of Salinity Exposure During Pregnancy on Child Health Outcomes (Controlling for Selective Migration)

	Dependent Variables:								
	HAZ	Stunted (HAZ < 2 SD)	Severely Stunted (HAZ < 3 SD)	WAH	Wasted (WAH < 2 SD)	Severely Wasted (WAH < 3 SD)	WAZ	Underweight (WAZ < 2 SD)	Severely Underweight (WAZ < 3SD)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: Sample of DHS Coastal Clusters Within 40 km (Restricted to Households Resident In the District for More than 7 years)									
salinity exposure	-0.0325**	0.0118**	0.0137***	-0.0314**	0.0066*	0.0052**	-0.0416***	0.0118**	0.0079**
(in utero)	(0.0162)	(0.0053)	(0.0048)	(0.0122)	(0.0037)	(0.0022)	(0.0120)	(0.0056)	(0.0036)
Observations	5,747	5,747	5,747	5,747	5,747	5,747	5,747	5,747	5,747
R-squared	0.3533	0.3040	0.2595	0.2157	0.1937	0.2148	0.3044	0.2538	0.2126
Panel B: Sample of DHS Coastal Clusters Within 40 km (Controlling for Post-Delivery Selective Migration)									
salinity exposure	-0.0293**	0.0061	0.0123***	-0.0307**	0.0083**	0.0047*	-0.0392***	0.0090	0.0070*
(in utero)	(0.0133)	(0.0049)	(0.0043)	(0.0151)	(0.0039)	(0.0025)	(0.0137)	(0.0055)	(0.0042)
migration within 3 years after delivery	0.0369	-0.0064	-0.0147	-0.0514	-0.0056	0.0016	-0.0089	-0.0136	-0.0067
	(0.0621)	(0.0224)	(0.0194)	(0.0637)	(0.0190)	(0.0092)	(0.0581)	(0.0255)	(0.0174)
Observations	4,925	4,925	4,925	4,925	4,925	4,925	4,925	4,925	4,925
R-squared	0.3909	0.3299	0.2778	0.2045	0.1883	0.1473	0.3236	0.2609	0.2137
Child, mother, household controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Weather controls	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ocean chemistry control (pH)	✓	✓	✓	✓	✓	✓	✓	✓	✓
District, yr of birth, mthb of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year of birth x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x month of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
District x year of birth FE	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: This table shows the coefficients of salinity exposure (measured as the average level 9 months prior to birth). The dependent variables in columns (1), (4), and (7) for height-for-age *z*-score, weight-for-height *z*-score, and for the weight-for-age *z*-score, respectively, are continuous. Dependent variables in columns (2), (5), and (8) are binary variables that equal to one if the child is stunted, wasted, and underweight, respectively, while in columns (3), (6), and (9), the binary variables equal to one if the child is severely stunted, severely wasted, and severely underweight, respectively. The child, mother, household controls include the child's age (in months) and gender, child birth order, mother's age at first birth, three dummy variables for the mother's education - primary, secondary, tertiary (with no education at all being the excluded category), mother's height, and the gender of the household head. Weather controls include minimum and maximum temperature, rainfall (in logs), the interaction between minimum and maximum temperature and log of rainfall, and humidity. We also control for the ocean's pH levels. All regressions are OLS and are weighted. Robust standard errors are clustered at the DHS cluster level. Panel A considers the sub-sample of DHS clusters that are within 40 km of the ocean, with children whose parents have resided in the current place of residence for greater than 7 years (median number of years). Panel B considers the sub-sample of DHS clusters that are within 40 km of the ocean, with a control dummy variable for post-delivery selective migration, which is equal to one if the mother migrated to the current place of residence of the interview within the first 3 years following delivery ***p<0.01, **p<0.05, *p<0.1