Neurodevelopmental Outcomes in Children Born to Climate Refugee Mothers in Bangladesh: Experiences from Cyclone Aila

*Khan NZ[1], Muslima H[2], Shilpi AB[3], Majumder SK[4], Khan AE[5]

Cyclone Aila hit the South-West coast of Bangladesh in May 2009, when in Dacope Upazilla over 50,000 people were left homeless as climate refugees (CRs) for over two years. We determined neurodevelopmental status of children born as CRs compared to their non-Climate Refugee (NCR) counterparts. Pregnant mothers were enrolled from May 2009 to April 2010 in entire Dacope in a study which profiled their health conditions. From among these mothers, 12 months post-Aila 267 CR mother-child dyads, and 552 NCR mother-child dyads were enrolled to assess their children's neurodevelopmental outcomes. There were significantly more landless families among CRs compared to NCRs (p value=0.0001; OR=1.86, 95% CI: 1.37-2.51). The mean±SD age at assessment of CR children was 8.52±4.57 months compared to a mean age 9.09±4.13 months of the NCR children (p=0.610). Neurodevelopmental Impairments (NDIs) were three times higher in the former (21.3%), compared to the latter (7.4%) group (p=0.0001; OR 3.83, 95% CI: 2.16 - 5.21). Specifically, expressive language (p value 0.002; OR 2.86, 95% CI: 1.46 – 5.57) and gross motor functions (p=0.007; OR 2.27, 95%CI 1.22 - 4.20) were the most significantly affected areas of impairment. Children born to CR mothers had a three times higher proportion of NDIs. The findings are of concern as in Bangladesh large populations are forced to leave their homes and become CRs annually. Optimum antenatal care of pregnant women as well as their offsprings within refugee situations needs to be ensured to prevent NDIs and poor quality of survival.

Key words: Cyclone, Refugee, Pregnancy, Children, Neurodevelopment

Introduction

Natural disasters are common in Bangladesh, including yearly floods and cyclones, especially in coastal areas[1]. Large populations are forced to leave their homes and take temporary refuge in safer areas, sometimes for substantial lengths of time[2]. A previous study from Bangladesh has reported significant rise in post-flood disabilities in children[3]. We report here the neurodevelopmental outcomes of children born to climate refugee (CR) mothers after a severe cyclone hit a coastal population of the country.

On 25 May 2009, Cyclone Aila hit a south-west coastal area of Bangladesh[4]. In one administrative sub-district (i.e. Dacope Upazilla within Khulna district) a tidal river embankment broke and the entire population (estimated to be over 50,000) had to take refuge on another eastern river embankment where the majority remained as CRs for over two years; and even till date, remain displaced[5,6,7].

During the same month i.e., May 2009, a study was undertaken to enroll pregnant women across the entire Dacope Upazilla to determine the effects of climate change on their overall health[8,9].

1. *Professor Naila Zaman Khan, Professor and Head, Department of Pediatric Neuroscience, Bangladesh Institute of Child Health, Dhaka Shishu (Children's) Hospital, Dhaka, Bangladesh; naila.z.khan@gmail.com*
2. *Dr Humaira Muslima, Senior Research Associate, Department of Pediatric Neuroscience, Dhaka Shishu (Children's) Hospital, Dhaka, Bangladesh*
3. *Dr Asma Begum Shilpi, Senior Developmental Therapist, Department of Pediatric Neuroscience, Dhaka Shishu (Children's) Hospital, Dhaka, Bangladesh*
4. *Dr Santosh K Majumder, Consultant in Obstetrics and Gynecology, Upazilla Health Complex, Dacope, Khulna, Bangladesh*
5. *Dr Aneire E Khan, Research Assistant, MRC/HPA Centre for Environment and Health and Department of Epidemiology and Biostatistics, School of Public Health, Imperial College London, UK*

*for correspondence

The enrolled population included both CR and non-CR (NCR) women. It was hypothesized that children born to the former group would have poorer neurodevelopmental outcomes than the latter, based upon reports from other studies on maternal stress during pregnancy[10] and specifically on the after-maths of natural disasters[11]. The objective of this study was to determine neurodevelopmental status of children born as CRs compared to their NCR counterparts 8 months after Cyclone Aila.

Methods
This was a follow-up cross-sectional study to assess neurodevelopment of a cohort of children born to CR-mothers (i.e., cases) compared to those born to their NCR counterparts (i.e., controls).

The base population of the study were pregnant mothers who were enrolled from May 2009 to April 2010 from 2nd trimester of pregnancy in a study which profiled their socio-demographic history, general health status and pregnancy-related health conditions in the entire Dacope Upazilla[8,9]. All children born to enrolled mothers (not inclusive, as many mothers had not yet delivered), were assessed for their neurodevelopment in their homes, between May to June, 2010, by Health Assistants, i.e., the government frontline health workers. This included a large sub-population of children who were conceived and born as CRs as their mothers had to leave their homes after Cyclone Aila and take refuge on another river embankment for over two years.

The Rapid Neurodevelopmental Assessment (RNDA) tool (12) was administered to all enrolled children in their homes by government frontline workers, i.e., Health Assistants (HAs). The tool was developed for use in children aged 0 to 24 months, and validated for use by generic child care professionals. The RNDA records neurodevelopmental impairments (NDIs), with severity ratings (not reported in this paper) under the following developmental domains: primitive reflexes (for 0 to 1 month), gross motor, fine motor, vision, hearing, expressive language, cognition, behavior, and seizures.

A short peri-natal history of the children was also recorded during the assessment.

Health Assistants (HAs) (i.e., government frontline health workers with minimum 12 years of schooling and a high school degree) were recruited

to conduct home-based neurodevelopmental assessments by administering the RNDA. A10-day training was provided to 9 HAs (2 males, 7 females), and 2 supervisors with college degrees, in Dhaka city by the Child Development Center, Department of Pediatric Neuroscience, Dhaka Shishu (Children's) Hospital.

All findings were computed on the SPSS database version 8. Mother's socio-demographic data was obtained from the original study database and merged with the perinatal and children's data collected for the present study. 'Any NDI' was computed if the child had a NDI in = >1 of the nine developmental domains.

Ethical clearance was obtained from the Ethical Research Committee of the Bangladesh Institute of Child Health, Dhaka Shishu (Children's) Hospital, Dhaka, Bangladesh. A written consent was taken from all mothers prior to interview and assessment of their children. All children found to have a NDI were referred to the Child Development Center ("Shishu Bikash Kendra' in *Bangla*) in the nearest government tertiary hospital, i.e., Khulna Medical College Hospital, Khulna, Bangladesh.

Results
Two hundred and sixty seven (267) CR mother-child dyads and 552 non-CR mother-child dyads were assessed (Table I). Mean ages of the mothers (23.13 years vs. 23.30 years, respectively) and children (5. 59 months vs. 5.75 months, respectively) were comparable. Maternal education, land ownership and ownership of a TV in their homes were significantly lower in the CR group (p values 0.0001, 0.0001 and 0.0001, respectively).

More CR mothers had had home-delivered babies (p value 0.006); by traditional birth attendants (p value 0.0001). Post-delivery, more numbers of CR newborns had difficulty in breathing with poor cry (p value 0.024); and/or were lethargic in the first week of life (p value 0.039) (Table I).

NDIs in CR children versus NCR children are compared in Table II. Any NDI (=>1 NDI) was found in 21.3% CR children compared to 7.4% in NCRs (p value 0.0001; OR 3.83, 95% CI 2.16 - 5.21). Within specific impairments, impairments in expressive language (7.9% in CRs vs. 2.9% in NCRs; p value 0.002; OR 2.86, 95% CI 1.46-5.57) and gross motor functions (8.2% vs. 3.2%, p value

0.007; OR 2.27, 95% CI 1.22 - 4.20) were more prevalent in CR children. NDIs in other specific functional domains were comparable and similar in the two groups.

Table I: Comparison of socio-demographic characteristics and perinatal histories of climate refugee (CR) versus non-climate refugees (NCR) mother-child dyads

Sociodemographic Variables	Climate Refugee (CR) Total = 267 (100%)	Non Climate Refugee (NCR) Total = 552 (100%)	F		P value	OR (95% CI)
Mean maternal age (±SD)	23.13±4.33	23.30±4.46	0.260		0.610	NC
Mean children's age (±SD)	05.59±3.41	05.75±3.66	0.377		0.539	NC
			Chi-square	df		
Maternal Education: none or primary school vs. > primary	114 (43.69)	165 (29.89)	50.256	1	0.0001	0.57 (0.42-0.77)
Land ownership: none vs. some	175 (65.5)	279 (50.5)	16.389	1	0.0001	1.86 (1.37-2.51)
TV ownership: none vs. owns	236 (88.4)	389 (70.5)	31.964	1	0.0001	3.19 (2.10-4.83)
Perinatal History						
Home delivered	206 (76,8)	373 (67.6)	14.619	4	0.006	
Delivered by traditional birth attendant	186 (69.7)	288 (52.2)	33.320	4	0.0001	
<12 hours taken to deliver	178 (66.7)	364 (65.9)	1.052	2	0.591	
Normal vaginal delivery	237 (88.8)	466 (84.4)	4.119	5	0.532	
Normal color of the newborn	255 (95.5)	533 (96.6)	1.470	2	0.480	
Difficult breathing and poor cry immediately after birth	19 (7.1)	20 (3.6)	4.841	1	0.024	2.03 (1.06-3.88)
Resuscitation needed	14 (5.2)	23 (4.2)	0.484	1	0.298	0.78 (0,39-1.55)
Baby lethargic in first week	16 (6.0)	17 (3.1)	3.948	1	0.039	0.49 (0.24-1.00)
Baby breast fed	265 (99,3)	547 (99.1)	0.052	1	0.588	0.83 (0.15-4.28)

NC = Not calculable

Table II: Comparison of neurodevelopmental impairments (NDIs) in children born as climate refugees (CR) (N=267; 100%) and non climate refugees (NCR) (N=552; 100%)

Neurodevelopmental impairments (NDIs)	CR children (N=267; 100%); NCR children (N=552; 100%)			
	Group	Number (%)	P value	OR (95% CI)
Gross motor	CR	22 (08.2)	0.007	2.27 (1.22-4.20)
	NCR	21 (03.8)		
Fine motor	CR	06 (02.2)	0.357	1.38 (0.48-3.93)
	NCR	09 (01.6)		
Vision	CR	01 (00.4)	0.276	0.34 (0.04-2.85)
	NCR	06 (01.1)		
Hearing	CR	03 (01.1)	0.606	1.03 (0.25-4.16)
	NCR	06 (01.1)		
Expressive language	CR	21 (07.9)	0.002	2.86 (1.46-5.57)
	NCR	16 (02.9)		
Cognition	CR	14 (05.2)	0.149	1.55 (0.76-3.14)
	NCR	19 (03.4)		
Behavior	CR	03 (01.1)	0.579	0.88 (0.22-3.44)
	NCR	07 (01.3)		
Seizures	CR	05 (01.9)	0.133	2.61 (0.69-9.81)
	NCR	04 (00.7)		
Any (=>1) NDI	CR	57 (21.3)	0.0001	3.83 (2.16-5.21)
	NCR	41 (07.4)		

Discussion

This study was the outcome of a severe cyclone (Cyclone Aila) which hit, among other areas, the Dacope Upazilla of Bangladesh in May 2009, resulting in the migration of thousands of villagers living within the safety of a river embankment to another river embankment where they had to remain for at least two years, many still displaced till date. Children who were conceived and given birth to as CRs were compared to their NCR counterparts at a mean age of 8 and 9 months, respectively, for their neurodevelopment. The significantly higher rates of poor neurodevelopmental outcomes in CR children highlight the need to address the plight of women who conceive as CRs and the subsequent well-being of their offspring.

NDIs were found to be over three times higher in CR children compared to NCRs (OR 3.83); and specifically in expressive language (OR 2.86) and gross motor functions (OR 2.27). These findings of poor neurodevelopmental outcomes of children born to CR mothers correspond with studies of antenatal stress in mothers and poor outcomes in their babies found in studies elsewhere. In a review of over 22 studies Talge et al.[13] conclude that if a mother is stressed while pregnant, her child is substantially more likely to have emotional or cognitive problems, including an increased risk of attentional deficit/hyperactivity, anxiety, and language delay. Talge et al.'s review findings were independent of effects due to maternal postnatal depression and anxiety. Our study findings of expressive language delay are similar to Talge's review findings. High rates of gross motor delays could be more related to perinatal complications which were two times higher (OR 2.03) in CR children and could signify a number of underlying causes such as preterm deliveries[14], etc; but which could not be specified in this study which was based upon maternal recall. Moreover, more CR mothers belonged to landless families (OR 1.86), i.e., an indicator of poverty, and which has been found to be a risk factor for later disability in children in a previous study in Bangladesh[15].

We still do not know what forms of anxiety or stress are most detrimental, but several factors can be considered. One socio-demographic study on the consequences of cyclones found that the richer families left for the city or found better living conditions leaving the poor in refugee-like situations[16]; and even among poor families, males migrated to cities to find a living, leaving the female to cope for her and their children[2]. As stated in the previous paragraph, our study found CR-mothers to be poorer, with significantly more deliveries at 'home' (a euphemism for the refugee shacks) by traditional birth attendants (or' dais') and with more perinatal complications in their newborns. Both poverty[17] and relationship with partner[13,18] have been shown to be sources of maternal stress which influences outcomes of child's well being subsequently.

The study had limitations. Firstly, more detailed information on children's perinatal history would have provided a better insight into their later neurodevelopment, For example, gestational age, birth weight, and severity of perinatal asphyxia could not be accurately determined. Secondly, more information regarding perinatal deaths was unavailable. Lastly, maternal stress was not measured, which could have led to more conclusive correlations with children's neurodevelopment as we have found in some of our previous studies[3,19].

Although with limitations, the strength of the study as a 'natural experiment' lies in the fact that infants' neurodevelopment was assessed of a CR cohort in comparison to a NCR cohort after a catastrophic cyclone made homeless thousands of women who subsequently conceived and gave birth to them, cannot be over emphasized.

Conclusion

This study was a 'natural experiment' after Cyclone Aila in the Dacope Upazilla of Bangladesh, where children's neurodevelopment was compared at a mean age of 8 and 9 months, respectively, between those born to CR-mothers, compared to their NCR counterparts. Overall NDIs were three times more prevalent in the CR cohort. Specifically, language and gross motor functions were most impaired. Significantly more CRs were poorer, delivered by untrained personnel and had had more perinatal complications, i.e., factors which could have added to the stress of their mother's delivering as CRs. The study has important implications for thousands of

Bangladeshi women of reproductive age, and pregnant women and their offspring, whose plight and stress need special attention by refugee rehabilitators and policy makers to provide them with a safer and more sensitive environment, optimum antenatal care, safe delivery, and a nurturing environment of their offspring, if their long-term quality of survival is to be ensured.

References

1. Islam MA. Tropical cyclones: coastal Bangladesh. Natural (1974). Climate Change Vulnerability and Adaptation in Asia and the Pacific. 1996:171-9.
2. Mallick, Bishawjit, Joachim Vogt. Cyclone, coastal society and migration: empirical evidence from Bangladesh. International Development Planning Review. 2013;34(3): 217-40.
3. Durkin M, Khan N, Davidson LL, Zaman SS, Stein ZA. The effects of a natural disaster on child behaviour: evidence for post-traumatic stress. American J Public Health. 1993;83: 1549-53.
4. Wikipedia website: http://en.wikipedia.org/wiki/Cyclone_Aila
5. Roy K, Kumar U, Mehedi H, Sultana T, Ershad DM. Initial Damage Assessment Report of Cyclone AILA with focus on Khulna District. Unnayan Onneshan-Humanity Watch- Nijera Kori, Khulna, Bangladesh. June 23, 2009:31. http://teacher.buet.ac.bd/ msalamkhan/teaching_msk_files/aila.pdf
6. Kumar U, Baten MA, Masud AA, Osman KS, Rahman MM. Cyclone Aila: One Year On. Natural Disaster to human sufferings. Unnayan Onneshan: Center for Research and Action on Development. 2010. Dhaka, Bangladesh. http://www.unnayan.org/documents/Climatechange/ailareport_humansuffering.pdf
7. New Age Online. High Court issue rule on repairing cyclone-hit dams. 11 March, 2015. http://newagebd.net/101970/hc-issues-rule-on-repairing-cyclone-hit-dams/#sthash.W4PuuvBx.dpbs
8. Khan AE, Ireson A, Kovats S, Mojumder SK, Khusru A, Rahman A, Vineis P, Labrese EVP. Drinking water salinity and maternal health in coastal Bangladesh: implications of climate change. Environmental Health Perspectives. 2011;119;(9):1328-32.
9. Khan AE, Scheelbeek PF, Shilpi AB, Chan Q, Mojumder SK, Rahman A, Haines A, Vineis P. Salinity in Drinking Water and the Risk of (Pre) Eclampsia and Gestational Hypertension in Coastal Bangladesh: A Case-Control Study. PLoS One. 2014 Sept 30;9(9):e108715.
10. Bergman K, Sarkar P, O'Conner TG, Modi N, Glover V. Maternal stress during pregnancy predicts cognitive ability and fearfulness in infancy. Journal of the American Academy of Child & Adolescent Psychiatry. 2007;46 (11): 1454-63.
11. Tees MT, Harville EW, Xiong X, Buekens P, Pridjian G, Elkind-Hirsch K. Hurricane Katrina-related maternal stress, maternal mental health, and early infant temperament. Maternal and Child Health J. 2010;14(4):511-8.
12. Khan NZ, Muslima H, Begum N, Begum N, Shilpi AS, Batra M, Darmstadt GD. Reliability and Validity of a Structured Tool for Neurodevelopmental Assessment of 0-24 month olds for use by Multiple Professionals in Bangladesh. Pediatrics. 2010 Apr; 125(4): e755-62.
13. Talge NM, Neal C, Glover V. Antenatal maternal stress and long-term effects on child neurodevelopment: how and why? Journal of Child Psychology and Psychiatry. 2007;48(3-4):245-61.
14. Khan NZ, Muslima H, Parveen M, Bhattacharya M, Begum N, Chowdhury S, Jahan M, Darmstadt GL. Neurodevelopmental outcomes of preterm infants in Bangladesh. Pediatrics. 2006 July;118(1):280-9.
15. Durkin MS, Khan NZ, Davidson LL, Huq S, Munir S, Rasul E, Zaman SS. Prenatal and postnatal risk factors for mental retardation among children in Bangladesh. Am J Epidemiology. December 2000;152(11):1024-33.
16. Mallick, Bishawjit, Rahaman RK, Joachim Vogt. Coastal livelihood and physical infrastructure in Bangladesh after cyclone

Aila. Mitigation and Adaptation Strategies for Global Change. 2011;16(6):629-48.

17. Donner W, Rodriguez H. Population composition, migration and inequality: The influence of demographic changes on disaster risk and vulnerability. Social Forces. 2008;87(2):1089-1114.

18. Brock RL, O'Hara MW, Hart KJ, McCabe JE, Williamson JA, Laplante DP, Yu C, King S. Partner support and maternal depression in the context of the Iowa floods. Journal of Family Psychology. 2014;28(6):832.

19. Khan NZ, Muslima H, Bhattacharya M, Darmstadt G et al. Stress In Mothers Of Preterm Infants In Bangladesh: Associations With Family, Child And Maternal Factors And Children's Neurodevelopment. Child Care Health Dev. 16 May 2008;34(5):657-64.