Trends of Microcephaly and Severe Arthrogryposis in Three Urban Hospitals following the Zika, Chikungunya and Dengue Fever Epidemics of 2016 in Jamaica

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SYPOPSIS:

Newborns with the characteristics of congenital syndrome associated with Zika virus (CSAZ) are being born in urban hospitals after the 2016 Zika Virus epidemic in Jamaica. Phenotypic features include microcephaly, craniofacial disproportion, neuro-imaging and neuro-pathological findings and arthrogryposis. A trend towards babies being delivered with small head circumferences, but not yet in the range of microcephaly and others with normal head sizes who were born to women who were symptomatic in pregnancy is also being observed. While, most babies with probable CSAZ are being born to asymptomatic women who did not report any symptoms related to arbovirus illness in pregnancy. Diagnosis is challenged by serological cross-reactivity between circulating flaviviruses. Team management is multidisciplinary to maximize the neuro-developmental potential of this vulnerable patient population.

ABSTRACT:

Introduction: Jamaica experienced its maiden Zika virus epidemic in 2016, while Dengue (serotypes 3 and 4) and Chikungunya were also circulating.
Aim: We describe initial trends in microcephaly and arthrogryposis observed by the clinicians from three urban birthing facilities during late 2016 to early 2017.
Methods: Reporting of infant microcephaly was required from all birthing facilities in Jamaica. Staff were to be trained in measuring the occipito-frontal head circumference (OFC) using World Health Organization's (WHO) standards. Affected newborns were to be referred for comprehensive pediatric evaluation.
Results: Hospital A reported 15 full term newborns with microcephaly, 10 were delivered between 10 November, 2016 to 06 January, 2017. All were full term newborns with OFC ranging from 28.5 to 31.5 cms, severe microcephaly with OFC's < -3 Z scores was seen in ten. Most (80% - 12) had the characteristic craniofacial phenotype of Congenital Syndrome Associated with ZIKA (CSAZ). Ten had neonatal ultrasounds which revealed intracerebral calcifications (4), dilated and/or asymmetric lateral ventricles (4), grossly overlapping sutures and/or closed or small fontanelles (3), cerebral atrophy (one) and absent frontal lobe sulcation with increased periventricular white matter (one). Computerised tomography (CT) scans revealed calcifications and dilated ventricles with thinning of cortical mantle (two others). Four mothers reported rash. The rate of microcephaly was estimated as 0.8% (10/1212) live births.

Hospital B, among 414/629 (65%) of primarily term vaginal live births reviewed during eight weeks of December to January 2017, 17 had OFC's $\leq$ 32 cms; eight patients had OFC < -2 Z score, six patients had OFC < -3 Z score and 3 patients had OFC at -2 Z score; 14 patients (3%) were therefore microcephalic. Seventeen had relative microcephaly. Among the 14 microcephaly cases, five term babies had low birth weight, three had seizures within 24 hours, 6/14 were adolescents aged 15-19 years and among 11/14 with uterine ultrasonography, one was abnormal with head-body discrepancy. Two had a cranial ultra-sonogram showing intra cerebral calcifications, dilated lateral ventricle and cerebral atrophy. One mother reported rash in pregnancy. Microcephaly rate was 1.63% (14/857 live births).

Hospital C identified 2% (1/43) microcephaly rate (OFC < 31.4 cms < - 2 Z scores) amongst symptomatic mothers during 01 May 2016 through 31 March, 2017. Four others had low OFC's (< 33 cms), but not in the range for microcephaly. Therefore, 88% (38/43) of babies born to symptomatic mothers had a normal OFC. Microcephaly rate for all live births for the period was 2.2% (26/1180). The monthly rate varied from 0% to 5% (6/118) peaking in March. Of two babies referred with severe arthrogryposis and microcephaly, one had characteristic evidence on nuclear magnetic resonance imaging of corpus callosum dysgenesis, occipital lobe cyst, cerebellar hypoplasia and intracranial calcifications. The other's CT scan of the brain revealed microcephaly with cortical atrophy, severe ventriculomegaly of lateral and third ventricles, fine calcifications in the thalami and basal ganglia bilaterally and in the right frontal lobe, with a huge posterior fossa cyst communicating with the 4th ventricle. He died and autopsy confirmed these findings. Cross-reactivity of serological tests for dengue and Zika virus challenged laboratory diagnosis in mothers and newborns.

Conclusion: Newborns with "characteristic CSAZ features" are being born in urban settings primarily to asymptomatic mothers in Jamaica. Diagnosis is challenged by serological cross-reactivity between the circulating flaviviruses. Team management is multidisciplinary and will be a costly intervention for developing countries to implement to maximize the neuro-developmental potential of this new and vulnerable population of children.

BACKGROUND:

In November 2015, Zika virus (ZIKV), was found to be associated with infant microcephaly in Pernambuco, Brazil and Guillain Barre syndrome in Salvador, Brazil (1). After about one million cases of ZIKV infection were identified from Brazil, the WHO declared this ZIKV outbreak a "Public Health Emergency of International Significance" on 1 February, 2016 (2) The purpose was to mobilise financial resources to explore a potential link between ZIKV and microcephaly and neurological syndromes.

ZIKV, a flavivirus capable of infecting nervous tissue, has now been conclusively linked to infant microcephaly from mother to child transmission, using the Bradford Hill and Shephard's criteria for proof of human teratogenicity (3). The congenital syndrome associated with ZIKV (CSAZ) is characterized by severe microcephaly with a partially collapsed skull, intracranial calcifications, ventriculomegaly, microphthalmia, cataracts, macular atrophy, severe arthrogryposis, intrauterine growth retardation and sensorineural hearing loss (4-8). Other perinatal features include fetal deaths, still births and oligohydramnios, and ZIKV has been identified from fetal brain, infant brain tissue and amniotic fluid (9). The congenital syndrome associated with ZIKV is consistent with the rare "fetal brain disruption sequence", with only 20 reported cases in the world before 2001(10,11). However, in characterizing the first 1501 cases of CSAZ from Brazil, the authors warned that "*Because many definite, or probable cases present normal head circumference values and their mothers do not report having a rash, screening criteria must be revised in order to detect all affected newborn babies*"(12,13).

As of March 17, 2017, the ZIKV epidemic has extended beyond Brazil, to include the Caribbean and North, Central and South America, with 84 countries/ territories reporting "mosquito-borne" ZIKV transmission since 2007and 61 with a reported "outbreak" from 2015 onwards.(14) Jamaica observed its first case of ZIKV in a four year old child on her return from Texas, USA, with her family in January 2016.(15) However, a recent phylogenetic study indicates that ZIKV was introduced into Jamaica in 2015, a year prior to this first case (16). This undetected circulation of ZIKV occurred not only in Jamaica and other Caribbean islands, but also widely throughout the Americas, including the USA (16). In the first 17 months of the epidemic, through 17 May, 2017, ZIKV surveillance notifications in Jamaica have approached 10,187 in total, comprising, suspected cases of 7,850 (77%) and laboratory confirmed cases of 203 (2%), with the epidemic peaking in June 2016.(Ministry of Health, Jamaica).

We now report herein, initial trends in microcephaly and severe arthrogryposis observed by a multi-disciplinary team of practicing clinicians, for three urban birthing facilities in Greater Kingston, Jamaica during the late 2016 to early 2017.

METHODS:

In December, 2015, the Jamaican Ministry of Health required reporting of microcephaly in newborns and pregnant women who fit the surveillance case definition for ZIKV infection (17-19). In May 2016, "rash only" was added to the case definition among pregnant women (15). Newborns with microcephaly were to be referred to pediatricians for comprehensive management and the CSAZ phenotype from other reports were considered (4-8).

In June 2016, the European Commission funded three consortia including "ZIKAction", to perform collaborative population-based research to better characterise the epidemic in Latin America, Caribbean, Europe and other sites. The "ZIKAction Kick Off" Research Meeting for the International ZIKAction Consortium was held at the

University of the West Indies' (UWI) Vice Chancellery and Regional Head Quarters, In Kingston, Jamaica, on October 30 through November 2, 2016. Some 35 international researchers from Europe, Latin America, USA and the UWI's Cave Hill and St Augustine Campuses, met with some 15-20 collaborators from the UWI's Mona Campus and the Jamaican Ministry of Health to discuss the implementation of the project (20). A legal memorandum of understanding has been signed between the UWI and the Jamaican Ministry of Health. This permits formal collaboration between the UWI and the Jamaican Ministry of Health to implement the protocol in Jamaica and data sharing between the parties, including international partners. The ZIKAction project will concentrate its efforts of the Maternal and Paediatric axis of ZIKV, chikungunya and dengue fever. The project will begin with the vertical transmission arm being implemented in three hospitals A, B and C and some selected feeder antenatal clinics. Hospital A is the largest maternity hospital in the English Speaking Caribbean, with approximately 7,500 deliveries in 2016 among its patient population from the Kingston metropolitan region. Hospital B performed some 5,000 deliveries that year for an urban catchment area, outside of Kingston. Hospital C is a University Teaching Hospital with some 1500 deliveries in 2016.

To educate paediatricians, obstetricians, related health care providers and students in training about this new illness and its complications in children and also to provide a background for the ZIKAction international research project, we are documenting the trends among the first few cases of microcephaly identified at these hospitals after the ZIKV epidemic began in Jamaica. We also report the phenotype of two of the most severely affected infants with microcephaly and arthrogryposis. Written permission was obtained from the infant's birth mothers, for their photographs to be taken and used for the purposes of medical education and research.

RESULTS:

In 2016, among the notifications to the Jamaican Ministry of Health that were related to arbovirus diseases 6,726 fit the case definition for ZIKV, 407 fit the case definition for chikungunya and 2,004 fit the case definition for dengue fever. There were a total of 203 laboratory confirmed ZIKV cases, seven confirmed cases of chikungunya and 159 confirmed cases of dengue virus (serotypes 3 and 4) infection. The initial trends of microcephaly observed by the clinicians practicing in three urban delivery hospitals (A,B,C) are reported, as follows.

Hospital A: Hospital A reported15 full-term newborns with microcephaly, 10 were delivered between 10 November, 2016 to 06 January, 2017. All were full term newborns with OFC ranging from 28.5 to 31.5 cms, severe microcephaly with OFC's < -3 Z scores was seen in ten. Most (80% - 12) had the craniofacial phenotype of CSAZ: including overlapping sutures (9), bi-temporal narrowing, or biparietal depression (8), small anterior fontanelle (6), closed fontanelle (4), increased skin folds of neck, or scalp (3), occipital prominence (3), relatively large hands (2) and feet (1), arthrogryposis (1), congenital heart disease (1) hypertonia (3) and tremors (one). Low birth weight was present in four. Ten had neonatal intra-cranial ultrasounds which revealed grossly overlapping sutures and/or closed or small fontanelles (3), intracerebral calcifications (4), dilated and/or asymmetric lateral ventricles (4), cerebral atrophy (one), lack of frontal lobe sulcation and increased periventricular white matter (one). Computerized tomography (CT) scans in two revealed calcifications, thinning of cortical mantle because of dilated ventricles (two). Nuclear magnetic resonance imaging (MRI) showed dilated ventricles and intracerebral calcifications (one other). One newborn had OFC of 32 cms, the craniofacial phenotype of CSAZ and ultrasonography with intracranial calcifications. Only four mothers reported symptoms consistent with ZIKV in pregnancy (rash with fever and/or joint pains). TORCH titers were negative in five and ZIKV PCR testing (done by the CDC) in one was negative. The rate of microcephaly was estimated as 0.8% (10/1212) live births.

Hospital B: In Hospital B, among 414/629 (65%) of primarily term vaginal live births reviewed during eight weeks of December to January 2017, 17 (4%) had OFC's $\leq$32 cms; eight patients had OFC < -2 Z score, six patients had OFC < -3 Z score and 3 patients had OFC at -2 Z score; 14 patients (3%) were therefore microcephalic. Their OFC's ranged between 26 to 31.5 cm. Seventeen others had relative microcephaly. Among the 14 microcephaly cases, five term newborns had low birth weight (1.9 to 2.49 kg), three had seizures within 24 hours. Only one patient had a low APGAR score of 3^{1} and 6^{5} minutes. Three had seizures within 24 hours of life.

All had severe microcephaly, two of these patients had cranial ultrasounds ; both showed calcifications and lateral ventricular dilatation. Cerebral atrophy was demonstrated on the ultrasound of one patient and on the MRI of the other. One patient also had arthrogryposis. Maternal ages ranged between 15-43 years. Only one mother had a rash and her baby had severe microcephaly. All other mothers were asymptomatic and none Zika Virus testing done. Eleven of the 14 mothers had ultrasound done in pregnancy with only one showing an abnormality of head body size discrepancy. Two mothers had HIV co-infection and their babies both tested HIV negative. Microcephaly rate was 1.63% (14/857 live births).

Hospital C: Hospital C performed active surveillance for mothers who were symptomatic in pregnancy with rash, joint pains, fever, red eyes and identified 6% (66/1180) such women during 1 May, 2016 through 31 March, 2017. Sixty five percent (43/66) have since delivered and 2.3% (1/43) had microcephaly (OFC < 31.4 cms < - 2 Z scores). Four others had low OFC's (< 33 cms), but not in the range for microcephaly. Therefore, 88% (38/43) of babies born to symptomatic mothers had a normal OFC. Microcephaly rate for all newborns for the period was 2.2% (26/1180). The monthly rate varied from 0% to 5% (6/118) peaking in March. Fifty newborns deliveries from symptomatic mothers also had low OFC's (<33 cms), but not in the range of microcephaly and these cases also peaked in March. Two mothers had HIV-co-infection, their babies both tested HIV-negative. Hospital C also accepted babies with severe microcephaly and arthrogryposis from Hospitals A and B for specialist consultations and investigations. Multi-disciplinary team management of babies probably included the obstetrician, neonatologist, infectious disease specialist, neurologist, neuro-radiologist, developmental pediatrician, physiatrist, orthopedist, audiologist, ophthalmologist, microbiologist, psychologist, social worker, nursing, public health and others. Case reports for the two most severely affected babies with microcephaly and arthrogryposis are reported as follows.

Case report 1 (Figure 1):

SS is a seven week old female whose mother (MT) had six antenatal visits. She reported recurrent upper respiratory tract infections and exposure to mosquitoes, but was asymptomatic for arbovirus illness. She had a normal intrauterine fetal ultrasonography at 16 weeks gestation. She had a spontaneous vaginal delivery at "Hospital B", cephalic presentation at 41 weeks gestation. APGAR scores were 7^{1} and 9^{5} minutes, respectively. Examination at birth was significant for weight 2.53 kg (< - 3 Z scores), length 48 cms (< - 2 Z scores) and OFC 26 cms (< - 3 Z scores). Dysmorphic features included severe microcephaly, prominent occiput, bitemporal narrowing, collapsed skull bones, small anterior fontanelle, low posteriorly-rotated ears, bilaterally, horizontal nystagmus, redundant skin folds at the nape, wide spaced nipples and large hands with clinodactyly. She had respiratory distress and generalized crackling and peeling of the skin. There was hypertonia evident in upper limbs with brisk reflexes throughout. Musculoskeletal system revealed severe arthrogryposis with hand and feet contractures, flexion deformities of both hips, hyperextension of the knees, with inability to dorsiflex with severe restriction in abduction, positive Barlow's, hypertonia and hypereflexia of the upper limbs, "rocker-bottom" feet with prominent calcaneii, sandals gap and abnormal creases on the soles. She also had displaced anus with lax anal tone. She had respiratory distress.

She was diagnosed as CSAZ with severe microcephaly and arthrogryposis and admitted to the Newborn Intensive Care Unit. Hospitalization was significant for neonatal seizures on day one, which was managed with phenobarbitone. Respiratory distress responded eventually on oxygen at 5L/minute by face mask. Cranial ultrasound revealed overlapping sutures, limiting visualization of the brain parenchyma. Dilated lateral ventricles with multiple tiny calcifications in the right frontal lobe were evident, with normal third and fourth ventricles. Hip ultrasound revealed laxity of both hips, with femoral head bulging in the fibrous labrum, bilaterally.

On reevaluation at hospital C at age six weeks, neurology consultations confirmed the dysmorphisms and revealed additional features of irritability, bi-frontal facial narrowing, wide nasal bridge, mild retrognathia, high arched palate, diastasis of recti abdominis, small umbilical hernia, external rotation of the hips, hyper-extension at the knees, extra crease beneath patella of both knees, wasting of left lower limbs distally > proximally, shortening

of the left lower limbs, fixed contractures to knees, distal tapering of fingers, clinodactyly, flat feet, overlapping toes, prominent calcaneii with "rocker bottom feet", hypertonia and hyper-reflexia to upper limbs and generalized xeroderma facial rash (Figure 1 A-C).

Ophthalmology consultation revealed bilateral optic atrophy. Nuclear MRI of the head and brain revealed collapsed skull bones. There was global hemispheric parenchymal volume loss, most significant posteriorly and in the temporal lobes. There was decreased salvation as well as sub-cortical parenchymal calcifications. There was dysgenesis of the corpus callous with associated colpocephaly as well as hypoplasia of the inferior vermis with wide communication between the fourth ventricle and a mega cisterna magna (Dandy Walker variant). Thin septations were noted in the occipital horns of the lateral ventricles (Figure 1 D and E). Results of mother and infant were identical for ZIKV and dengue serologies: DENV NS1 antigen – negative, DENV IgM - negative, Dengue IgG – positive, ZIKV IgM – negative, ZIKV IgG – positive. Mother's HIV and Syphilis serologies were negative. ZIKV PCR of infant's urine and blood remain outstanding.

She is receiving ambulatory management by Orthopedics, Early Stimulation Center, Infectious Diseases, Neurology and Ophthalmology. She now lives with her mother and maternal grandparents and she is breastfed

Case report 2 (Figures 2,3):

JB is a 6-week-old male whose mother (KJ) gave an antenatal history significant for rash, fever and joint pains at 4/40 gestation. He was delivered spontaneously at "Hospital A" at term (37 weeks and 6 days) gestation. His APGAR scores were 4^{1}, 6^{5}, respectively and he required resuscitation.

JB had multiple congenital anomalies at birth including severe microcephaly -OFC 28.0 cm < -3 Z scores; severe intrauterine growth retardation with low birth weight of 2.02 kgm < -3 Z scores; length 48 cms < -3 Z scores. Systemic involvement included multiple abnormalities including the neurological system with CT scan of the brain revealing microcephaly with cortical atrophy, severe ventriculomegaly of lateral and third ventricles, fine calcifications in the thalami and basal ganglia bilaterally and in the frontal lobes. A huge posterior fossa cyst was noted in communication with the 4^{th} ventricle, consistent with Dandy Walker Syndrome and aqueductal stenosis.

There were multiple dysmorphisms with facial disproportion, redundant scalp skin, overlapping cranial sutures, comparatively large ears and face, posteriorly rotated R>L ears, bitemporal narrowing and horizontal nystagmus. Respiratory system showed hypoplasia of the right lung with abnormal lobulations, elevation of the diaphragm, associated with respiratory distress syndrome at birth. He required hospitalization for over four weeks in the Newborn Special Care Unit and over one week on Pediatric Service, where he remained oxygen dependent with a baseline respiratory distress of 50-80 breaths/min and intercostal recessions. Cardiovascular findings by echocardiogram showed a small patent ductus arteriosus along with small inter-atrial communication of an atrial septal defect and elevated pulmonary pressures. Abdominal abnormalities included gastro-esophageal reflux and a right inguinal hernia. There was a patulous anus. Genital examination showed bilateral cryptorchidism and chordee of the penis (Figure 2E). Musculoskeletal system revealed severe congenital arthrogryposis with multiple limb contractures characterized at birth with fixed flexion and adduction deformities in limbs, both knees hyperextended, R. internally rotated, L. externally rotated, with camptodactyly (middle three digits), clinodactyly, overlapping fingers and prominent calcaneii with "rocker bottom feet" (Figure 2 A, C and E). Subsequently the child developed fixed adduction of arms, internally rotated at shoulder, extended at elbow, "frozen hips" and knees, bilaterally.

He was referred to "Hospital C" at age four weeks for further consultations. He was noted to have persistent respiratory distress. He also had a hoarse cry and was evaluated by the Otolaryngology Service for vocal cord dysfunction. Arterial blood gases showed a relative hypercarbia and hypoxemia off oxygen. He was therefore maintained on 1 L O_2. Throughout the course of his hospitalization, he was noted to have increasing requirement for oxygen with no change in his other clinical parameters and no worsening of his chest radiographic findings.

He required enteral feeds via a naso-gastric tube due to a weak suck and poor gag reflex. At age six weeks, he developed worsening respiratory distress associated with oxygen desaturations. Despite increased concentration of oxygen, control of seizures with anti-epileptic medications, bag valve ventilation with intermittent positive pressure ventilation, intubation and continuous positive airway pressure, resuscitative efforts failed and he died. Significant investigations included CMV IgM: negative; toxoplasmosis IgM: negative; rubella IgM: negative; dengue IgM: negative; HIV: negative; Sickle Cord Blood: A + A2. Karyotyping normal male (thus excluding Trisomy 18). Autopsy confirmed his aforementioned physical findings (Figure 3). Investigations for blood, urine, spinal cord and brain for ZIKA PCR are pending at the time of manuscript submission.

DISCUSSION

Microcephaly is not new to Jamaica (21). However, since the 2016 ZIKV epidemic, several newborns with the characteristics of CSAZ, including microcephaly with craniofacial disproportion, neuro-imaging and autopsy findings as well as arthrogryposis are now being recognized in urban settings in Jamaica. A trend towards babies being delivered with low head circumferences at birth, but not yet in the range of microcephaly and still others with normal head sizes who were born to women who were symptomatic in pregnancy is also being observed. In addition, the majority of the babies with possible CSAZ are being born to asymptomatic women who did not report any symptoms related to arbovirus illness (ie., rash, fever and joint pains) in pregnancy. The USA's Centers for Diseases Control and Prevention along with the American Academy of Pediatrics as well as recent guidelines issued from Brazil's Ministry of Health have all called for increased recognition, or expanded case surveillance definitions with treatment and care of this diverse group of affected infants.(12,22,23)

As of 17 May, 2017, there were 837 surveillance notifications to the Jamaican Ministry of Health from mothers who reported symptomatic illness in pregnancy, with 707 (84%) suspected reports meeting ZIKV clinical case definition and 75 laboratory-confirmed cases. Notified cases of CSAZ totaled 181 and 52 were suspected CSAZ, comprising other congenital anomalies 4; microcephaly 48, with non-severe cases of 36, severe cases of 12, probable cases of 3 and confirmed cases none. All of these babies were reported to be living with their mothers.

ZIKV displays broad tissue tropism, including the nervous tissue with clinical effects most pronounced when mother is infected during early pregnancy (24-26). These cases appear characteristic of CSAZ (4-8). Prominent features included severe microcephaly with flattening, or sloping of the forehead, overlapping sutures, closed anterior fontanelles, pointed occiput, relative enlargement of the face and ears, excess skin folds on the scalp and neck, arthrogryposis and seizures. The two case reports included these features and other characteristics of CSAZ. These included neuroimaging and/or autopsy confirmation of several other supporting findings of multiple calcifications, abnormal gyral patterns, ventriculomegaly, prominent extra-axial spaces, hypoplasia of the brainstem and cerebellum and callosal dysgenesis (8,27,28). Several other features that seem new to the literature, including chordee of the penis and cryptorchidism, possibly linked to arthrogryposis with flexion of the hips in utero limiting testicular descent. Similarly, an abnormal chest wall and pulmonary hypoplasia with persistent neonatal respiratory distress leading to ultimate demise, as reported here, could be due to oligohydramnios. "Rocker bottom feet" were present in both severely affected babies and have not been previously described. While congenital heart disease was evident, it is unclear whether this is related to CSAZ, or simply consistent with background rates of congenital heart disease in the population. Optic atrophy was also seen, while macular scarring and focal retinal pigmentation, although rare, are more consistently reported with CSAZ (29,30). Outstanding research questions include whether these features comprise the full CSAZ syndrome and whether there are other risk factors. A case control study is now being conducted to better characterize these patterns. Data will be collated internationally, including here in Jamaica, an island-population, congruent with the "ZIKAction PEDS" research work package, to augment the one other published case control study (31,32).

Infant microcephaly has a multi-factorial etiology. There is clinicopathological and experimental evidence indicating neurotrophic properties of Zika virus (33,34). The virus has been identified in infected brain tissue at electron microscopy and its entire genome has been isolated from infected neuronal tissue (35). The virus appears

to cause severe neuronal injury which is evidenced by diffuse astrogliosis and calcifications. While several of these babies have the characteristic phenotype of CSAZ, there is as yet no conclusive laboratory evidence linking any of these microcephalic babies to ZIKV infection. Molecular diagnostics (usually ZIKV PCR) are required to meet WHO criteria. Even when performed, specific ZIKV PCR tests from newborn blood and CSF samples can still be negative in live-born cases (8). Mothers with infants who have CSAZ, may demonstrate a positive ZIKV RT-PCR for up to 100 days.(36) Results of current serologic testing (IgM and IgG) in Jamaica have been challenging to resolve because of issues related to cross reactivity, most likely due to similarities between the envelope proteins of dengue and ZIKV flaviviruses, as well as previous dengue exposure (37). These cases are therefore characterized as "probable" cases of CSAZ, as has also been reported for the majority of other published reports (4-8). Diagnostics also need to be developed and be responsive to asymptomatic mothers, who may have babies who are either born with CSAZ, or develop characteristic features later on. Diagnostics also need to be improved for babies with possible CSAZ. Microcephaly has also been found among children with vertically-acquired Chikungunya fever (38). Dengue, Chikungunya and ZIKV can be transmitted from mother to child in pregnancy and intrapartum and the complications of oligohydramnios, preterm delivery, low birth weight, miscarriage and infant microcephaly have been reported with Chikungunya and ZIKV. Dengue, Chikungunya and ZIKV all have shown attributable morbidity in Jamaican children.(39-41) Dengue, of itself, has not been reported as a cause microcephaly (42). Clarification is still needed to determine if a previous, or current dengue co-infection, maybe a facilitator that augments the congenital anomalies attributed to ZIKV.

Babies with CSAZ are known to have early growth restriction and neuro-developmental challenges (6) Severe neuro-developmental anomalies are also possible long-term, including poor balance, coordination, motor development, speech, hyperactivity, seizures, reduced hearing, sight and swallowing reflexes would be expected; growth restriction is expected with poor feeding and swallowing, short stature and failure to thrive. These babies would also have educational and learning challenges. Other long-term concerns include multiple and recurrent hospitalisations, recurrent aspiration pneumonias, other infections and related challenges

Infants are to be evaluated for intracranial neurological abnormalities with cranial ultrasound and for those with a closed anterior fontanelle, nuclear MRIs, or CT scans. Similarly, the TORCHS and other arboviral perinatal infections are to be excluded. Team management should be multidisciplinary involving highly specialized services, including the obstetrician, neonatologist, infectious disease specialist, neurologist, neuro-radiologist, developmental pediatrician, physiatrist, orthopaedist, audiologist, ophthalmologist, microbiologist, psychologist and social worker to facilitate the best possible outcomes.

Long-term care should also embrace a holistic multidisciplinary, collaborative team approach – similar to our HIV treatment and care model (43). Long-term management should include a research program with standardised data extraction instruments, database, data management and information technology personnel. The team would comprise paediatricians, neurologists, developmental specialists, nutritionists, speech therapists, social workers, research nurses, orthopaedists, physiotherapists, special educators and others. Ideally, family-based care with appropriate maternal support should be considered. However, facilities for state care, similar to the HIV model should also be embraced. However, the capacity to provide optimal care for these babies, in high numbers, needs to be considered, as this relates to health, maintenance and other economic costs. The Ministry of Health has established a fund for caring for these vulnerable infants for the first 18 months of life. Similar to HIV and children with other severe neurological abnormalities, it is anticipated that a subset of these children will most likely be abandoned in hospital and will therefore require long-term institutional care.

The main limitation is absence of confirmed ZIKV diagnostics in mothers and babies. Results of PCR testing of blood, urine, CSF, spinal cord, or brain are outstanding due to interruption of service for this laboratory test at the time of manuscript submission. The presence of ZIKV in the CSF is currently the gold standard for proving CNS infection in affected babies. Similarly, infant infection can be predicted if ZIKV is isolated from mother's amniotic fluid. There are also limitations in current methodologies for serologic diagnosis of ZIKV infections in asymptomatic mothers and babies, especially in the settings of dengue co-circulation. Although most babies had

characteristic features of CSAZ, results of evaluations for TORCH infections were not always available. Measurements of the OFC also appeared to be biased towards rounding to 0.5 cm, or up to a whole number, instead of recording to within one decimal place. This study was also biased towards describing infants with the most severe CSAZ phenotypes of severe microcephaly and severe arthrogryposis.

Jamaica experienced a ZIKV outbreak in 2016, while chikungunya and dengue were also co-circulating. Clinicians are now seeing cases of microcephaly and a trend towards decreasing head circumferences in some babies. Some newborns, most of whom were born to asymptomatic mothers, showed distinct classical characteristics of ZIKV congenital syndrome (CSAZ). While many others, with normal OFC's, are being delivered to mothers who were symptomatic in pregnancy. Jamaica has yet to confirm its first case of congenital syndrome linked to ZIKV (PCR) isolation. Notwithstanding, these babies require a coordinated, multi-disciplinary system of holistic care with access to family counseling and support. This will be challenging and costly for developing countries, such as Jamaica, to successfully implement while still necessary to improve the neuro-developmental potential of this new and vulnerable population of children.

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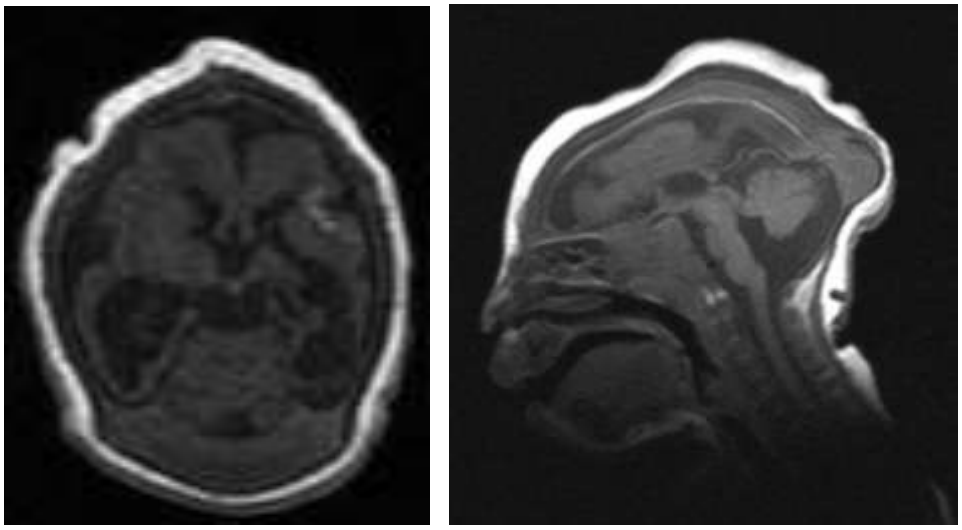
Figure 1

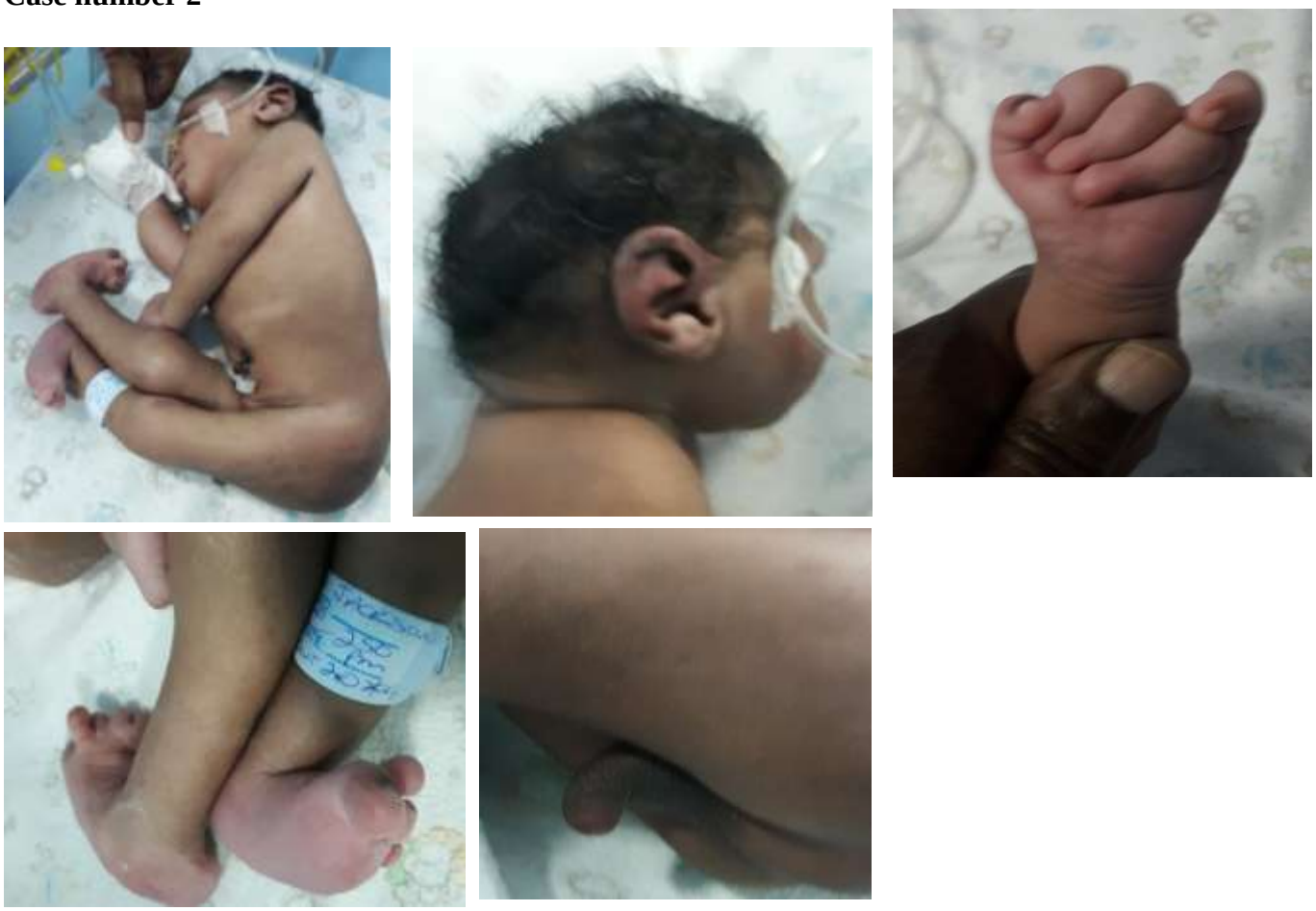
Case number 1

Panels (1A,B,C above) show female infant at age six weeks (sucking at mother's breast), showing severe microcephaly, sloping forehead, facial dysproportion with "over sized" facial features, appearance of proptosis, horizontal nystagmus with bilateral optic atrophy. Infant also displays clenched upper limbs with cortical fisting, diastasis of "recti abdomini" muscles, severe arthrogryposis and "rocker bottom" feet.



Panels (1D,E above) reveal infant's magnetic resonance imaging of the skull and brain displaying marked microcephaly, collapsed skull bones with extensive scalp folding. There is decreased hemispheric parenchymal volume loss with decreased salvation and evidence of calcification (D). There are septations in the occipital horns of the lateral ventricles as well as evidence of a vermian hypoplasia, in keeping with a Dandy Walker variant.

FIGURE 2 (Panels A,B,C,D,E)
Case number 2



Photograph A,B,C,D,E – showing male newborn on day three of life with severe microcephaly, collapsed skull with prominent occiput and severe arthrogryposis, involving multiple joints, with dislocated knees and hips, prominent calneii (rocker bottom feet), camptodactyly (permanently bent fingers, toes), clinodactyly (curved fingers and toes), chordee penis (penis curved downwards), bilateral crytorchidism (undescended testes) and brachydactyly of the toes (shortened toes).

Figure 3
Case Number 2
AUTOPSY PHOTOGRAPHS

Figure 3. A) External autopsy photograph. Severe congenital arthrogryposis with joint deformities and marked muscle wasting.

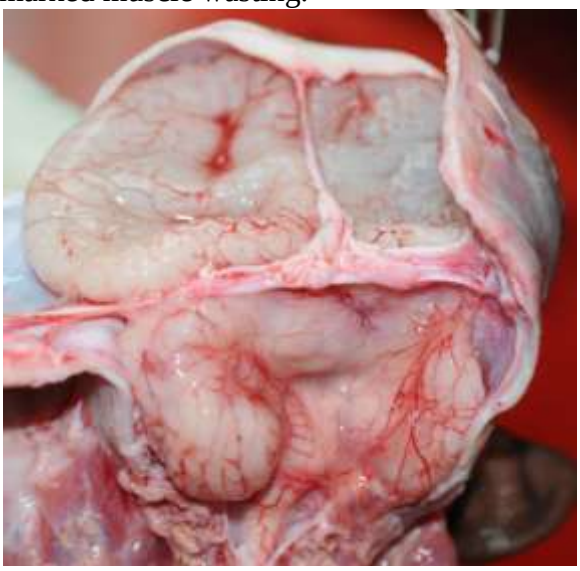


Figure 3. B) Autopsy photograph of opened cranial vault, posterior view. Ruptured posterior fossa cyst with absence of the cerebellar vermis consistent with Dandy-walker malformation. There is also marked hydrocephalus with thinning of the cerebral cortex.

Source: ZIKA V Microcephaly in Jamaica, VJH, STH, UHWI, 14 Feb; 30 Apr; 1,8,23,24,25,27,29,30,31 May, 2017; 1,2,3,7 Jun, 2017