

Health Outcomes for Children in Haiti Since the 2010 Earthquake: A Systematic Review

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Abbreviations:

DHS: Demographic and Health Survey
EBD: emotional and behavioral difficulties
LNS: lipid-based nutrient supplement
PTSD: posttraumatic stress disorder
UN: United Nations

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Abstract

Background: Haiti remains the poorest country in the Americas and one of the poorest in the world. Children in Haiti face many health concerns, some of which were exacerbated by the 2010 earthquake. This systematic review summarizes published research conducted since the 2010 earthquake, focusing on health outcomes for children in Haiti, including physical, psychological, and socioeconomic well-being.

Methods: A literature search was conducted identifying articles published from January 2010 through May 2016 related to pediatric health outcomes in Haiti. Two reviewers screened articles independently. Included research articles described at least one physical health, psychological health, or socioeconomic outcome among children less than 18 years of age in Haiti since the January 2010 earthquake.

Results: Fifty-eight full-length research articles were reviewed, covering infectious diseases (non-cholera [N = 12] and cholera [N = 7]), nutrition (N = 11), traumatic injuries (N = 11), mental health (N = 9), anemia (N = 4), abuse and violence (N = 5), and other topics (N = 3). Many children were injured in the 2010 earthquake, and care of their injuries is described in the literature. Infectious diseases were a significant cause of morbidity and mortality among children following the earthquake, with cholera being one of the most important etiologies. The literature also revealed that large numbers of children in Haiti have significant symptoms of posttraumatic stress disorder (PTSD), peri-traumatic stress, depression, and anxiety, and that food insecurity and malnutrition continue to be important issues.

Conclusions: Future health programs in Haiti should focus on provision of clean water, sanitation, and other measures to prevent infectious diseases. Mental health programming and services for children also appear to be greatly needed, and food insecurity/malnutrition must be addressed if children are to lead healthy, productive lives. Given the burden of injury after the 2010 earthquake, further research on long-term disabilities among children in Haiti is needed.

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Introduction

Haiti has long been considered one of the world's most impoverished nations, ranking 163 out of 188 countries on the United Nations (UN) Human Development Index,¹ and having one of the poorest economies in the Western hemisphere. According to the United Nations International Children's Emergency Fund (UNICEF; New York USA) State of the World's Children 2015 Report, Haiti's under-five mortality was 73/1,000 live births (ranking 32 from the bottom) and its infant and neonatal mortality rates were high at 55 and 25 per 1,000 live births, respectively.² Many children in Haiti have difficulty accessing food, clean water, adequate housing, and medical care, and they face high rates of violence, sexual abuse, and exploitation.³ Free and accessible public education for children is limited, decreasing enrolment rates for those who cannot afford private education.⁴

On January 12, 2010, a 7.0 magnitude earthquake struck Haiti. The resulting destruction was massive and widespread, including an estimated 316,000 deaths, 300,000 people injured, 1.3 million people displaced, 97,294 houses destroyed, and 188,383 houses damaged in the capital and in the southern region of the country.⁵ It is estimated that the earthquake affected over 1.5 million people and that children and youth represented more than one-half of those impacted by the disaster.⁶ The 2010 earthquake made it more

("Haiti"[Mesh] OR Haiti*[tw] OR Haiti*[ad])	AND	("Child"[MeSH Terms] "Infant"[mesh] OR "Adolescent"[MeSH Terms] OR "Pediatrics"[MeSH] OR child*[tiab] OR infant*[tiab] OR newborn*[tiab] OR neonat*[tiab] OR baby[tiab] OR babies[tiab] OR adolescen*[tiab] OR toddler*[tiab] OR teen*[tiab] OR boy[tiab] OR boys[tiab] OR gir*[tiab] OR pediatric*[tiab] OR paediatric*[tiab] OR youth*[tiab])
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Table 1. PubMed Search Strategy

challenging for children in Haiti to access the basic necessities of life and exacerbated pre-disaster concerns about child protection and violation of human rights, including trafficking, restavèks (child slaves), sexual violence, and exploitation.⁶ In addition, recovery from the earthquake was complicated by a widespread cholera epidemic that resulted in many additional lives lost.

Given heightened concern about child health and the welfare of children following the earthquake and the cholera epidemic, this systematic review summarizes published peer-reviewed research conducted since the earthquake that focuses on physical health, psychological health, or socioeconomic outcomes for Haitian children. The goal was to provide a comprehensive summary of the recent and post-earthquake child health research to be useful for identifying potential research gaps as well as informing programming and services for children and the allocation of resources.

Methods

Search Strategy

The purpose of this literature review was to summarize and report on research focused on health outcomes for children in post-earthquake Haiti (regardless of whether the health outcome was a direct result of the earthquake or independent of the earthquake). To identify research publications on health outcomes among children in post-earthquake Haiti, PubMed (National Center for Biotechnology Information, National Institutes of Health; Bethesda, Maryland USA); Embase (Elsevier; Amsterdam, Netherlands); PsychINFO (American Psychological Association; Washington DC, USA); LILACS (Latin American and Caribbean Center on Health Sciences Information Knowledge Management, Bioethics, and Research Area; Rua Vergueiro, São Paulo, Brazil); Web of Science (Thomson Reuters; New York, New York USA); and Sociological Abstracts (ProQuest; Ann Arbor, Michigan USA) were searched from January 10, 2010 through May 2016 using the terms "Haiti" in combination with "Child," "Adolescent," "Infant," "Pediatric," "Toddler," "Baby," "Boy," "Girl," or "Youth." The full PubMed search strategy is provided in Table 1, and equivalent searches were conducted in the other peer-review databases. A grey literature search was also conducted using the Grey Literature Report (New York Academy of Medicine; New York, New York USA) and Open Grey (Institut de l'Information Scientifique et Technique; Vandoeuvre-lès-Nancy, Cedex, France), plus a number of pre-selected academic think tanks or centers, as well as the websites of pre-selected nongovernmental organizations, UN, and government agency websites. A complete list of grey literature sources is provided in Table 2. Because a broad definition of health and health determinants underpinned this review, any research reporting child physical health, psychological health, or socioeconomic outcomes were included. Children were defined as persons less than 18 years of age. Articles that focused on the

following were excluded: (1) non-health outcomes; (2) adults 18 years of age or older; (3) Haitian refugees or migrants living outside of Haiti; (4) data collected prior to the January 2010 earthquake; or (5) humanitarian response or systems evaluation. Articles that were published in abstract format only, were written in languages other than English or French, or for which full-length articles could not be accessed were also excluded.

Results

A total of 647 articles were identified, each of which was independently screened by two reviewers (AD and MM) who had been previously trained in the screening process. Articles that described peer-reviewed research with at least one physical health, psychological health, or socioeconomic outcome among individuals aged 18 years or under in Haiti since the earthquake in January 2010 were included. A total of 58 articles were retained by consensus between the two reviewers. Screening discrepancies and uncertainties were resolved through a panel discussion with a third reviewer (SB). Each of these 58 articles was then reviewed in detail by one of two investigators (AD or MM) who extracted data for inclusion in the review. Full details of the screening results, as well as the types of health outcomes described, are illustrated in Figure 1.

Included articles were classified by topic into one of eight themes, including: infectious diseases (non-cholera [N = 12] and cholera [N = 7]), nutrition (N = 11), traumatic injuries (N = 11), mental health (N = 9), anemia (N = 4), abuse and violence (N = 5), or other topics (N = 3). Some articles focused on more than one topic, and the categories were not mutually exclusive. While some articles (N = 19) focused on direct earthquake-related outcomes, other articles (N = 43) were broader and reported health outcomes more generally since the January 2010 earthquake. A majority of articles were cross-sectional in design (N = 39), while 12 used a cohort design following participants over time. Four studies were case-control studies, and three studies were randomized controlled trials. Overall, the age range of children included in articles was three to 17 years.

Infectious Diseases

Infectious diseases (cholera in seven studies and non-cholera in 12 studies) were among the most commonly reported child health illnesses in Haiti since the 2010 earthquake (Table 3)^{4,7-23} and caused significant morbidity and mortality, as reflected in this review of the literature. Both cholera and non-cholera diarrheal illnesses were common, in addition to a variety of respiratory infections, malaria, and wound/skin infections. After the earthquake, cholera was thought to have been re-introduced in Haiti after the country had been cholera-free for almost a century.²³ With no pre-existing immunity to cholera, significant morbidity and mortality resulted, particularly in the

Grey Literature Specific Sites:
1. The Grey Literature Report
2. Open Grey
Academic Centers / Think Tanks:
1. Global Health Council
2. Center for Global Development
3. The United Nations University
4. RAND Corporation
5. The Woodrow Wilson Center
6. The Bill and Melinda Gates Foundation
7. Center for Global Health Research / University of Toronto
8. Emergency Trauma Care Project
9. Centre for Research on the Epidemiology of Disasters (CRED)
NGOs, UN, and Government Agency Websites:
1. MEASURE Evaluation
2. MSF
3. Epicenter
4. International Rescue Committee
5. International Medical Corps
6. Oxfam International
7. Oxfam Great Britain
8. GIZ/GTZ
9. International Committee of the Red Cross
10. Centers for Disease Control and Prevention
11. World Health Organization
12. Humanitarian Practice Network
13. UN High Commission for Refugees
14. UN Development Program
15. Inter-Agency Standing Committee
16. UNICEF
17. JHPIEGO

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Table 2. Grey Literature Sources

Abbreviations: GIZ/GTZ, Deutsche Gesellschaft für Internationale Zusammenarbeit; JHPIEGO, Johns Hopkins Program for International Education in Gynecology and Obstetrics; MSF, Médecins Sans Frontières; NGO, nongovernmental organization; UN, United Nations; UNICEF, United Nations Children's Fund.

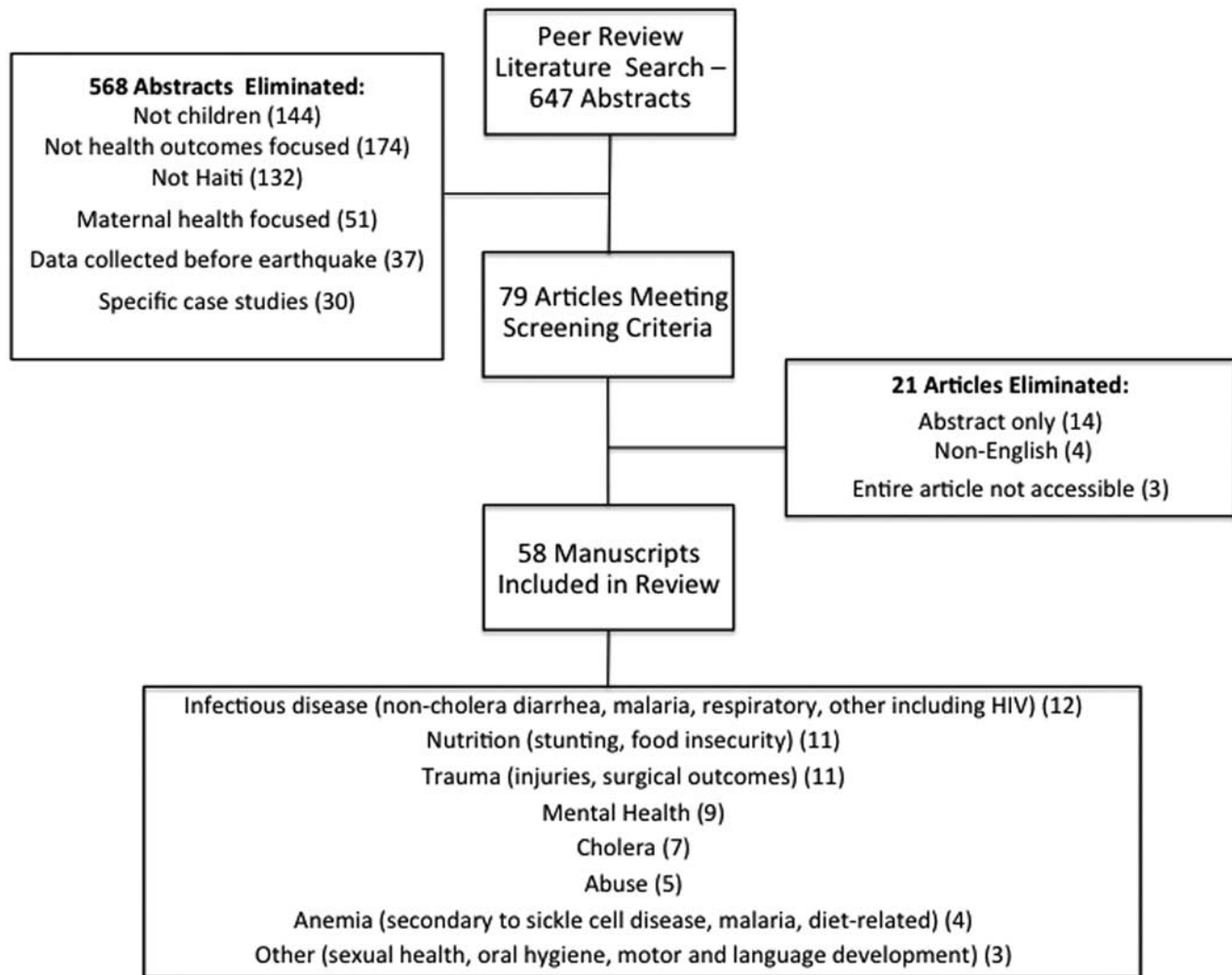
Artibonite district, and children were among those most affected. Table 3 provides further details of reported infectious disease outcomes.

Nutrition and Food Security

Eleven studies focused on nutritional status and food security among Haitian children. A 2012 household survey studying children aged 0 to 59 months reported that 4.3% of children had wasting, 22.2% of children had stunting, and 10.5% of children were underweight.²⁴ Despite the earthquake, this represented a decline in each of the categories when compared to the 2005-2006 Haiti Demographic and Health Survey (DHS), and the rural-urban gap had also narrowed in all categories.²⁴ However, a follow-up survey in 2013 showed no significant further improvements in wasting, stunting, and underweight children.²⁵ Data from the DHS and the Multiple Indicator Surveys were also used to determine the prevalence of child stunting and differential access to food between restavèk and non-restavèk children in Haiti. Among 13,907 Haitian children aged five to 14, non-restavèk children had higher rates of insufficient access to food (68.5%) in comparison to restavèk children (53.1%).²⁶ In additional analysis of 2015 DHS data, the national stunting prevalence in children under five years of age was 31.0% among the poorest families, 21.0% among average income families, and 8.0% among the richest families.²⁷ Overall, the population prevalence of stunting was found to have decreased since 2000.²⁷

The post-earthquake literature also included nutritional data from hospitals and medical centers. A 2012 review of medical records for children aged six to 11 months at Fort Saint Michel Health Centre in the Nord Department of Haiti determined that 30.2% of the 583 children had mildly to moderately stunted growth.²⁸ Between April and June 2010, records from baby tents established in heavily earthquake-impacted areas revealed that 65.7% of infants less than 12 months of age who were unable to breastfeed were considered underweight, 14.8% were considered moderately underweight, and 19.5% were considered severely underweight.²⁹ Among children under the age of five in the Milot Valley, 41.7% had mild or moderate stunting, 4.4% had severe stunting, 37.3% had mild or moderate wasting, 3.8% had severe wasting, 46.0% were mildly and moderately underweight, and 4.3% were severely underweight.³⁰ Among children between five and 14 years of age in Milot Valley, 45.9% had mild or moderate stunting, 2.9% had severe stunting, 38.2% had mild or moderate wasting, 3.5% had severe wasting, 48.7% were mildly or moderately underweight, and 1.7% were severely underweight.³⁰

There were several studies on nutritional supplementation among Haitian children. In a randomized controlled trial among three to 13-year-olds in Cap Haitien, a fortified ready-to-use supplement increased the body mass index *z score* and percentage fat mass compared with control at each time point ($P < .001$).³¹ In 2013, 1,167 children aged three to 13 years in northern Haiti were randomized to receive either an unfortified cereal bar (Tablet Yo), a fortified ready-to-use supplement (Mamba), or a control group without supplementation.³¹ In longitudinal modeling, Mamba supplementation increased body mass index *z score*, while both Mamba and Tablet Yo increased mean fat mass.³¹ The authors concluded that fortified, ready-to-use supplementary food decreased the odds of wasting by 55.0% when compared to supplementation with an unfortified cereal bar or a control group.³¹ And finally, a study conducted in an urban slum area followed mother-child pairs with singleton births less than one year old dividing them into three groups: 191 control pairs, 196 pairs with a three-month old child, and 202 pairs with a six-month old child.³² The latter two groups received a daily sachet of a



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Figure 1. Screening Results and the Types of Health Outcomes Described.

lipid-based nutrient supplement (LNS) and attended a clinic at the start of each month; LNS supplementation for six months significantly increased the length-for-age z score and the effects were sustained at six months. However, morbidity and developmental outcomes did not differ by trial arm.³²

Two additional studies reported on food security among Haitian children. In the months after the earthquake, 17.2% of Port-au-Prince households reported that their child had gone hungry in the previous month, 22.5% stated that their child had skipped a meal in the past month, and 22.6% reported that they had reduced the size of their children's meals in the previous month.³³ School attendance and household amenities prior to the earthquake were found to have a negative correlation to going hungry while age, gender, and health had no association with going hungry.³³ Household damage, sense of security, levels of posttraumatic stress disorder (PTSD), and size of household were found to be positively correlated with skipped meals and meal size reductions after the earthquake.³³ Rural-to-urban migration among seventh grade students after the earthquake was associated with increased food security due to a wider diversity of available foods and increased peer social interactions.³⁴

Trauma, Injuries, and Care

In the immediate relief effort following the 2010 earthquake, many aid organizations and medical groups treated children with earthquake-related injuries, and these were subsequently reported in the literature (11 studies). A Swiss Confederation medical team working at a field hospital, for example, managed 471 pediatric patients with traumatic injuries, including 42.0% with crush injuries to their extremities, 22.0% with axial injuries, 6.8% with other musculoskeletal injuries, 3.4% with open head injuries, and 2.7% with each of compartment syndrome and a non-musculoskeletal surgical injury.³⁵ In a hospital run by Project Medishare in Port-au-Prince from January through June 2010, seven children died (41.2% of all earthquake-related deaths at that hospital) and 159 survived (29.8% of all surviving patients).³⁶ The US Naval Ship *Comfort* also contributed to the management of pediatric earthquake injuries by providing surgical treatment to 237 children, with many of those (167 out of 237) having extremity injuries (134 fractures, 29 soft tissue injuries, and four vascular injuries).³⁷ Furthermore, 4.2% of patients had burns, 8.8% had head and neck injuries, 0.8% had pelvic injuries, 1.7% had spinal injuries, and 10 children required an amputation.³⁷

Aboard the US Naval Ship *Comfort*, 409 pediatric patients were treated in January 2010 with 47.0% of those patients requiring admission for their traumatic injuries, including 29 open fractures, 64 lower limb fractures, 17 upper limb fractures, and eight axial skeleton fractures.³⁸ At the Fort de France University Hospital in Martinique, 23 of 53 pediatric patients evacuated from Haiti after the earthquake were admitted for surgical care of earthquake-related injuries in January and February 2010, eight with open fractures, 10 with tissue damage, three with open depressed skull fractures, one with peritonitis, and one with gaseous gangrene.³⁹ At the Israeli field hospital in Port-au-Prince, 57.0% of the 272 pediatric patients treated in the 10 days immediately following the earthquake had injuries directly resulting from the earthquake.⁷ These injuries included 48 (15.0%) open fractures, 52 (16.4%) open wounds, 29 (9.2%) crush injuries, 29 (9.2%) superficial injuries, eight (2.6%) contusions, five (1.6%) dislocations, five (1.6%) head injuries, and six (1.8%) other or unspecified injuries.⁷

Pediatric injuries treated at six hospitals in the Central and Artibonite districts of Haiti in the six months prior to the earthquake included 14 traumas/burns, nine fractures and dislocations, two amputations, and two burns among the 423 overall pediatric surgeries conducted. This injury pattern was compared by Hughes et al to that in the six months following the earthquake with an increased volume of 670 operative pediatric patients as well as a much higher injury incidence: 259 traumas/burns, 195 fractures and dislocations, 23 amputations, and nine burns.⁴⁰

In a stratified, cluster sample survey one year after the earthquake, Doocy et al reported injury ratios of 40/1,000 and 39/1,000 for children less than nine years of age and children 10 to 19 years old, respectively.⁴¹ The mortality ratios for children less than nine years of age and children 10 to 19 years old were 20/1,000 exposed and 19.5/1,000 exposed, respectively.⁴²

The post-earthquake literature also included a report on critical care provided to pediatric patients in Haiti since 2010. Following the earthquake, Project Medishare admitted nine infants and 20 children to neonatal and pediatric intensive care units, respectively, at a Port-au-Prince field hospital.⁴² Among these patients, there was one burn injury, one traumatic superior mesenteric artery tear, and two traumatic brain injuries.⁴³ The only study examining the prevalence of disabilities and access to services among Haitian children was conducted in 2012. In this report, 2.9% of 656 children under five years of age had an identified disability, and these children were less likely to be in school and had more limitations and restrictions on activity than control group children.⁴⁴

Anemia

Four peer-reviewed publications reported findings associated with studies of sickle cell and diet-related anemia in Haitian children. The prevalence of the sickle cell genotypes HbSS and HbSC was one in 173 newborns, which was twice that for African Americans living in the US, and thus representing a significant burden of disease.⁴⁵ In a 2012 study, the prevalence of diet-related anemia was 30.0% overall (1,405 of 4,721 children) but was as high as 51.5% among children six to 11 months of age.²⁵ A variety of nutritional supplementation and deworming programs had been implemented to address this high prevalence of anemia.²⁵ For instance, a research trial in Cap Haitien randomized three to 13 year old school children to receive fortified snacks versus regular snacks in Cap Haitien and measured hemoglobin concentrations at three points in time using World Health Organization (WHO; Geneva, Switzerland) anemia and severe anemia thresholds.⁴⁶

Seventy-one percent of children were anemic and 2.6% were severely anemic. Parent-reported vitamin A supplementation and deworming were positively associated with higher hemoglobin concentrations.⁴⁶ Diet supplementation with a fortified ready-to-use supplementary food reduced the odds of developing anemia by 28.0% compared to controls.⁴⁶

Mental Health

Nine published studies examined mental health among children in Haiti, including research on the psychological impact of the disaster. A 2011 study in Port-au-Prince examined the levels of traumatic exposure, PTSD symptoms, and social support of 540 children aged two to 18 years who had experienced the earthquake but not received psychological care.⁴⁷ The investigators reported high rates of PTSD symptoms, particularly among females, and noted higher rates of social support for children attending school in comparison to children who were not in school. Social support was significantly correlated with school attendance, level of traumatic exposure, and PTSD symptoms.⁴⁷ However, there was no significant correlation between level of traumatic exposure and PTSD symptoms.⁴⁷ Using a questionnaire self-administered to 658 children aged 10 to 17 years of age, Derivois et al reported that among children 10 to 13 years of age, 9.9% had low PTSD symptoms, 55.3% had average PTSD symptoms, and 34.9% had high PTSD symptoms.⁴⁸ For children between the ages of 14 and 17 years, 5.3% had low PTSD symptoms, 55.5% had average PTSD symptoms, and 39.1% had high PTSD symptoms.⁴⁸ Other investigators used the PSYCa 3-6 questionnaire to measure psychological disturbance among children and found that all but one of the 166 participants had directly witnessed and/or were victims of the earthquake.⁴⁹ Using nine as a threshold of disturbance, the average disturbance score for participants was 9.8, with 51.8% of children scoring over nine and 25.0% of children scoring over 12.0.⁴⁹ Males were observed to have higher scores in comparison to females.⁴⁹ The PSYCa 3-6 questionnaire was also used to analyze the relationship between environment and psychological health for children three to six years of age. In this study, males had greater psychological disturbances than females, and the number of siblings, neighborhood violence, and the perception of environmental harm were positively correlated with psychological disturbances.⁵⁰

Several institution-based studies had also examined mental health among children in Haiti since the earthquake. Cénat et al investigated PTSD symptoms and depression among 872 children at 12 schools and two homeless shelters in zones of Port-au-Prince that were heavily affected by the earthquake.⁵¹ In this 2012 study, 63.7% of children met criteria for significant distress on the peri-traumatic distress inventory, 36.9% of children had PTSD, and 46.2% of children had depression.⁵¹ Another school-based study investigated psychological consequences of the earthquake among nine to 12-year-olds, based on distance from the epicenter (urban versus rural) and studied whether children separated from their biological parents/families displayed more severe symptoms.⁵² Children from Port-au-Prince (16 miles from the epicenter) and Mirebalais (50 miles from the epicenter) were enrolled. The study found that all children displayed significant symptoms of depression, anxiety, and trauma, regardless of their location.⁵² Children who lived in orphanages scored lower for anxiety and PTSD symptoms than did children living with their biological families, and thus orphanages appeared to have played a protective role in Haitian children's lives.⁵² Other groups of children had also

been the focus of research on mental health in Haiti. For instance, using the Child Psychosocial Distress Screener, 104 Pan American and Olympic games athletes aged 12 to 18 years were compared to 104 gender and age matched children from several schools and orphanages.⁵³ The authors reported no significant differences in psychosocial scores between the athletes (19.0%) and the control group (21.0%).⁵³

Two identified studies evaluated the impact of psychological health interventions on children in Haiti. The first determined the efficacy of an eight-week yoga intervention on reducing trauma-related symptoms as well as emotional and behavioral difficulties (EBD) in children aged seven to 17 years living in orphanages.⁵⁴ Children in both the yoga group and the aerobic dance group had lower trauma-related symptoms and EBD, although the results were not statistically significant.⁵⁴ Participants in the yoga program reported that they enjoyed the sessions and that their overall well-being was improved as a result.⁵⁴ The second study assessed the effect of a psychosocial support program offered to children relocated in Port-au-Prince compared with a control group. Using the Ute Sodeman's Psychosocial Assessment Questionnaire for Children, 68.0% of children in the psychosocial support program had severe levels of PTSD and 40.9% had severe depression versus 50.0% and 20.5% in control group, respectively.⁵⁵ The authors concluded that these surprising results could be explained by the absence of equivalence between the two groups in terms of demographics and because the subjects were not randomly selected.⁵⁵

Abuse and Violence

Of the 58 studies reviewed, five focused on issues of abuse or violence among Haitian children. In 2012, Flynn-O'Brien et al used the Violence Against Children Survey to document the incidence of physical violence against children in Haiti. In this report, 69.9% of children aged 13 to 17 years reported lifetime experiences of physical violence with most of the violence perpetrated by parents or teachers as a form of punishment or discipline.⁵⁶ Almost all of the children in this study were punched, kicked, whipped, or beaten, and 11.0% had experienced abuse with a knife or other weapon.⁵⁶ Restavèk children, children kept as household domestic servants in Haiti, were also surveyed to identify their experiences of physical abuse. Restavèk children aged five to 14 years reported less physical abuse (8.6%) than non-restavèk children (16.6%).²⁶ However, restavèk children had significantly lower school attendance and more labor experiences.²⁶

Following the earthquake, there was considerable media attention around rising incidents of sexual violence in Haiti. A household study in Port-au-Prince estimated that 5,209 girls and 324 boys from 1,732 households had been sexually assaulted after the earthquake in 2010.⁵⁷ Nation-wide surveys in Haiti estimated the lifetime prevalence of sexual violence to be 21.2% in males and 25.7% in females before 18 years of age, but only 6.6% of boys and 10.0% of girls had received formal support services following experiences of sexual violence.⁵⁸ The lifetime prevalence of experiencing unwanted, completed sex before age 18 in Haiti was estimated to be 7.6% for males and 9.0% for females.⁵⁸ Sumner et al also reported specifically on sexual violence among boys in Haiti and found that 23.1% had experienced some form of sexual violence before the age of 18 and 18.0% of 327 participants were 10 years of age or less at the time of the first sexual assault.⁵⁹ This work generated an estimated prevalence of unwanted sex of

8.8%, which was higher than estimates for Kenya and Cambodia.⁵⁹

Other

There were three remaining studies included in the review that were single articles on sexual health,⁶⁰ oral hygiene,⁶¹ and motor and language development.²⁸ Among 200 adolescents, 60.0% were found to have engaged in sexual intercourse. Males were 3.52 times more likely to have had sex, 5.42 times more likely to report sexual debut before the age of 14, 9.75 times more likely to have more than one sexual partner, and 3.33 times more likely to not have used a condom during their last sexual encounter than females.⁶⁰ Adolescents living with parents or family were less likely to report having engaged in unprotected sex.⁶⁰

The oral hygiene of 56 children from an urban orphanage and 64 children from a suburban orphanage was evaluated in October 2010.⁶¹ Children in the suburban orphanage had significantly fewer caries than those in the urban orphanage and there had been an overall increase in the prevalence of dental caries after the earthquake. It was speculated that the observed trends may be related to sweets distributed by medical teams after the disaster.⁶¹

The final article was from a study investigating the relationship between stunting and the motor/phonetic language acquisition among 583 children aged six to 11 months. In this longitudinal study, stunting was significantly associated with slower motor and phonetic language acquisition, and dietary diversity, consumption of eggs and oil, length-for-age, and stunting were predictive of motor and language acquisition.²⁸

Discussion

The objective of this review was to provide a comprehensive summary of recent child health literature in Haiti (using the January 2010 earthquake as a cutoff for the literature search) with the goal of informing health programming and services as well as identifying potential research gaps. In total, 58 unique articles were identified, spanning topics such as infectious disease, nutrition and food security, trauma and injury, mental health, anemia, abuse, and violence. Most of the research was cross-sectional in design (47 of 58 studies) and many of the studies were conducted in the greater Port-au-Prince area. It is also noteworthy that because the literature search was completed prior to Hurricane Matthew in October 2016, it did not capture research concerning the health impact of that disaster, which was a Category 4 storm that affected more than 350,000 people in Haiti and exacerbated the cholera epidemic.⁶²

Although the authors of this review did not look at the prevalence of studies prior to the earthquake and are not able to comment on a specific change in volume, it is obvious that the earthquake did affect the research landscape with one-third of the included studies (19/58) having focused on direct earthquake-related outcomes. These direct earthquake-related studies highlight the important impact of this large-scale disaster on children, particularly in terms of traumatic injuries and the potential for long-term disabilities. It is noteworthy, however, that only a single identified study examined disabilities among Haitian children. Given the amount of destruction caused by the 2010 earthquake and the anticipated resultant disabilities, this may be an area that warrants further study.

As is common across humanitarian crises, this review highlights that infectious diseases were an important cause of

morbidity and mortality in Haiti after the earthquake. As illustrated in Table 3, the most commonly reported infections were diarrheal illnesses, which typically result from lack of access to safe water, poor hygiene, and over-crowded living conditions due to displacement and crowded sheltering. Given its highly infectious nature and the lack of pre-existing immunity, the cholera outbreak that followed the 2010 earthquake had a significant impact on the health of Haitian children with the Center for Disease Control (CDC; Atlanta, Georgia USA) reporting over 82,000 cases of cholera in children under the age of five, representing 90.0% of all cholera cases reported in that study.²³ Cholera was not endemic to Haiti and this represented the first cholera cases in the country in almost 100 years.²³ The disruptions in public health and health care infrastructure, as well the already stretched resources resulting from the earthquake, made it all the more challenging to mount an effective response to the cholera epidemic. While other reported infectious diseases such as malaria may have resulted from earthquake-related loss of housing or loss of preventative measures like mosquito nets, it is not possible to make any such conclusions from this review.

Eleven of the 58 articles focused on malnutrition among Haitian children with high reported prevalence of stunting and wasting.^{24–34} A 2012 study suggested declines in rates of malnutrition after the 2010 earthquake.²⁴ This may be a reflection of food aid and medical care distributed by humanitarian organizations after the disaster, and it is unclear if these positive trends will continue now that the disaster is well into the rebuilding phase and financial resources are being diverted to other emergencies. Another study highlighted food insecurity, but is it difficult to know how the earthquake may have affected this since the focus was exclusively post-earthquake.

The current review included nine published studies focused on mental health in Haiti. Many of these articles reported a very high prevalence of PTSD, peri-traumatic stress, anxiety, and depression among children since the earthquake. Distance from the epicenter of the earthquake did not appear to mediate these symptoms.⁵¹ Li et al reported similarly surprising results after the Wenchuan 2008 earthquake, where individuals who lived in highly disaster-affected areas were less concerned about safety and health in comparison to those who lived further from the epicenter.⁶³ Following the Haiti earthquake, higher rates of social support were noted for children attending school, and children who lived in orphanages had lower scores for anxiety and PTSD symptoms than did children living with their biological families. These findings are consistent with a 2011 meta-analysis which showed that school-based support was useful for reducing mental health symptoms among children in humanitarian settings.⁶⁴ Although higher rates of suicidal ideation were reported after the 1999 Turkey earthquake,⁶⁵ the current review did not identify any studies that examined suicidal ideation among children and adolescents after the 2010 earthquake. It is noteworthy that because of the on-going stressors that many youth in Haiti face on a regular basis (poverty, violence, and food insecurity), it is difficult to definitively link mental health outcomes to the earthquake.⁵²

Abuse and violence were also identified as areas of concern with over two-thirds of children reporting physical violence, primarily at the hands of teachers and parents. Interestingly, *restavèk* children reported less physical abuse, although they were more likely to be deprived of an education and were often engaged in child labor. Studies conducted after the earthquake report a high prevalence of sexual violence, including one in five boys and one in four girls with a lifetime experience of sexual abuse. These prevalence estimates for sexual violence are similar to those for the

United States as estimated by the National Sexual Violence Resource Center (Harrisburg, Pennsylvania USA; one in four for girls and one in six for boys).⁶⁶

Although the search strategy was designed to capture studies in post-earthquake Haiti related to all aspects of child health, studies have largely focused on clinical presentations and outcomes. However, large natural disasters such as the 2010 earthquake often weaken many aspects of society, including public health infrastructure, educational services, employment opportunities, housing, and basic services such as water, sanitation, and electricity. Knowledge gaps associated with these broader determinants of health, such as earthquake-related changes in poverty, occupational opportunities that affect child and family life, or disruptions in schooling, were under-represented in this review and are a recommended area of priority for future research. In future research, including research on the health impact of Hurricane Matthew, it will be important to consider the impact of these social determinants of health on children.

Limitations

This study is limited by its inherently retrospective nature and its reliance on a large number of case studies. Although six peer-review databases were searched in addition to the grey literature, it is possible that relevant articles were missed and a total of five non-English/non-French articles were excluded. Because the review only included literature published after the 2010 earthquake, it was not possible to juxtapose health outcomes for children before and after the disaster. Without reviewing baseline health conditions, other than the direct earthquake-related traumatic injuries, it is impossible to draw definitive conclusions regarding the role of the earthquake in determining health outcomes.

Future Research

Several areas for future research were identified. First, it is recommended that long-term disability among children and youth in Haiti be studied. Given the large numbers of reported injuries among children after the 2010 earthquake, there may be a significant unmet need for rehabilitation, physiotherapy, and occupational therapy services. Second, future studies should more closely examine the social determinants of health, such as adequate housing, access to safe water, attendance in school, and social support structures.

Conclusions

The post-earthquake research landscape for child health in Haiti is characterized by relatively few published studies and a heavy representation of cross-sectional designs. Many children were injured in the 2010 earthquake, and since then, children have been significantly impacted by infectious diseases, particularly diarrhea and including cholera. Access to clean water and proper sanitation will be important for reducing these preventable causes of morbidity and mortality in the future. Malnutrition and food insecurity are other important health concerns for children in Haiti, despite on-going efforts to address hunger. Large numbers of Haitian children have significant symptoms of PTSD, peri-traumatic stress, depression, and anxiety, and future health programs for children and youth in Haiti should consider mental health as a priority.

Authors' Contributions

AD and MM screened and extracted data. AD and MM summarized findings from the articles and provided a rough draft of the results section. CD analyzed the results and provided the

discussion. SB conceived the idea and was a major contributor in writing the methods, results, and discussion. All authors edited and approved the final manuscript.

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Time	Location	Outcome	Citation
Gastrointestinal			
10 days following earthquake	Israeli field hospital (Port-au-Prince, Haiti)	24 out of 272 (7.5%) patients had gastroenteritis	Farfel et al, 2014 ⁷
Weeks 3 - 31 after earthquake	16 different MSF clinics (Dufort, Jacmel, Leogane, and Port-au-Prince, Haiti)	4,262 cases of watery diarrhea, 207 cases of bloody diarrhea, 65 cases of suspected typhoid	Polonsky et al, 2013 ⁸
January 2010 - December 2012	HUP (Port-au-Prince), HSC (Port-au-Prince), HSN (Artibonite Department) and SMJ (Southeast Depart.)	Diarrhea accounted for 3,582 of 10,621 (34.0%) admissions and 62 of 540 (11.5%) in-hospital deaths in children < 5; 88.5% and 96.8% of admissions and deaths respectively were in children under 2 years	Derby et al, 2014 ⁹
May - June 2010	Jolivert Safe Water for Families Programs (Nord-Ouest and Artibonite Depart. Haiti)	Among households using water chlorination/clean buckets, 32.0% versus 52.0% of children had diarrhea in the previous 48 hours with 59.0% reduced odds (OR = 0.41; 95% CI, 0.21-0.79); impact greatest for children < 5 but all children in participant households had significantly less diarrhea (14.0% vs. 21.0%)	Harshfield et al, 2012 ¹⁰
November 2010 - May 2011	18 primary care clinics (Leogane and Magandou, Haiti)	948 of 6632 (11.7%) and 86 of 567 (9.8%) pediatric patients had abdominal pain, intestinal worms, or diarrhea in Leogane and Magandou, respectively	Dickstein et al, 2014 ¹¹
January 2011 - December 2013	HUP (Port-au-Prince), HSC (Port-au-Prince), HUEH (Port-au-Prince), HSD (Port-au-Prince), HSN (Artibonite Depart.) and SMJ (Southeast Depart.)	8,063 of 31,565 (26.0%) admissions were for diarrhea; 224 of 8,063 (2.7%) children admitted with diarrhea died during hospitalization (13.0% of in-hospital deaths)	Vinekar et al, 2015 ¹²
April 2012 - March of 2013	HUP (Port-au-Prince), HSC (Port-au-Prince), HSN (Artibonite Depart.), and SMJ (Southeast Depart.)	550 hospitalizations of children aged 0-17, 4 cases of shigella, 2 cases of salmonella, 52 cases of rotavirus, and 252 cases without an identifiable pathogen	Steenland et al, 2013 ¹³
2012-2013 academic year	Christianville private school clinics (Gressier/Leogane region of Haiti)	In kindergarten, 8 of 286 (2.8%) had diarrhea and 30 of 280 (11.0%) had intestinal infections; in primary school, 19 of 591 (3.4%) had diarrhea and 93 of 591 (17.0%) had intestinal infections	Beau De Rochars et al, 2015 ⁴
Cholera			
October - December 2010	10 Haitian departments and Port-au-Prince	82,599 cholera cases in children < 5 (90.0% of all cases); 39,435 children < 5 hospitalized with cholera (91.0% of cholera hospitalizations); 1,908 cholera deaths among children < 5 (92.0% of all cholera deaths)	CDC, 2010 ²³
October 2010 - July 2011	GHESKIO CTC and ORPs (Port-au-Prince, Haiti)	Children < 5 accounted for 7.0% of cholera cases in the 1 st epidemic wave, 8.0% of cases in the inter-epidemic period, and 12.0% of cases in the 2 nd epidemic wave; children 5 - 19 accounted for 28.0% of cholera cases in the 1 st epidemic wave, 16.0% of cases in the inter-epidemic period, and 22.5% of cases in the 2 nd epidemic wave	Valcin et al, 2013 ¹⁴
October 2010 - October 2012		13.1% of cholera cases, 43.6% of cholera hospitalizations, and 7.8% of cholera deaths were among children < 5; inverse relationship	Barzilay et al, 2013 ¹⁵

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Table 3. Summary of Studies on Infectious Diseases Outcomes Among Children in Haiti (continued)

	Health facilities (Artibonite, Centre, Grande Anse, Nippes, Nord, Nord-Est, Nord-Ouest, Ouest, Port-au-Prince, Sud, and Sud-Est Depart. Haiti)	between 7-day average proportion of patients ≤ 5 and total number of reported cholera cases	
March - April 2011 and October 2012 -March 9 2014	Grande Saline Commune (Artibonite Department, Haiti)	16.0% of participants 5-12 reported cholera diagnosis in the cholera serosurvey, of the participants tested, 42.0% were <i>Vibrio cholerae</i> seropositive; cholera vaccine effectiveness for children ≤ 5 was 50.0%, with only 9 cholera cases and 31 controls	Jackson et al, 2013 ¹⁶
April 2011 - November 2012	GHEKIO CTC and ORPs (Port-au-Prince, Haiti)	Among children < 5 , 118 bacteriological analyses performed at CTCs, 72 bacteriological analyses performed at ORPs, while only 79 xTAG tests performed at CTCs, 44 xTAG tests performed at ORPs; for children 5 -15, 111 bacteriological analyses performed at CTCs, 34 bacteriological analyses performed at ORPs, while only 67 xTAG tests performed at CTCs, 20 xTAG tests performed at ORP	Charles M et al, 2014 ¹⁷
April 2012 - March of 2013	HUP (Port-au-Prince), HSC (Port-au-Prince), HSN (Artibonite Depart.), and SMJ (Southeast Depart.)	27 of 202 (13.0%) children 0-1, 57 of 117 (49.0%) children 2-4, and 163 of 231 (71.0%) children 5-17 were diagnosed with cholera	Steenland et al, 2013 ¹³
April 2013	St. Marc, Haiti	47 children aged 1-5 and 51 children aged 6-17 received 2 doses of Shancol cholera vaccine 14 days apart; 74.0% of older children and 73.0% of younger children showed a ≥ 4 -fold increase in vibriocidal titer against <i>vibrio cholerae</i> , 45.0% of older children and 61.0% of younger children showed a ≥ 2 -fold increase in serum O-antigen specific IgA antibody levels against <i>vibrio cholera</i>	Charles RC et al, 2014 ¹⁸
Respiratory			
10 days post-earthquake	Israeli field hospital (Port-au-Prince, Haiti)	9 of 272 patients had pneumonia (2.8%), 8 of 272 (2.5%) had URTIs	Farfel et al, 2014 ⁷
Weeks 3 - 31 after earthquake	16 different MSF clinics (Dufort, Jacmel, Leogane, and Port-au-Prince, Haiti)	12,852 of 102,054 children < 5 had acute respiratory infections (12.6%), 8 cases of suspected tuberculosis	Polonsky et al, 2013 ⁸
November 2010 - May 2011	18 primary care clinics (Leogane and Magandou, Haiti)	2195 of 6632 patients (33.0%) and 85 of 567 (15.0%) patients were diagnosed with an URTI in Leogane and Magandou, respectively	Dickstein et al, 2014 ¹¹
January 2011 - December 2013	HUP (Port-au-Prince), HSC (Port-au-Prince), HUEH (Port-au-Prince), HSD (Port-au-Prince) and SMJ (Southeast Depart.)	9,183 of 31,565 (29.0%) admissions were children with RTIs; 301 of 9,183 (3.3%) died during hospitalization (17.0% of in-hospital deaths)	Vinekar et al, 2015 ¹²
2012-2013 academic year	Christianville private school clinics (Gressier/Leogane region of Haiti)	In kindergarten, 27 of 286 (9.6%) had URTIs, 72 of 286 (25.7%) had LRTIs, and 2 had asthma; In primary school, 47 of 591 (8.3%) had URTIs, 103 of 591 had LRTIs (18.2%), and 4 had asthma	Beau De Rochars et al, 2015 ⁴
Malaria			
Weeks 3 - 31 after earthquake	16 different MSF clinics (Dufort, Jacmel, Leogane, and Port-au-Prince, Haiti)	Malaria or fever of unknown origin presumed to be malaria in 939 children of 102,054 (0.92%) consultations	Polonsky et al, 2013 ⁸
March - April 2010	Community clinics (Leogane and Jacmel regions of Haiti)	317 patients tested positive for malaria on a rapid diagnostic test; 26 (8.2%) children < 5 and 87 (27.4%) children 5 - 14	Townes et al, 2012 ¹⁹

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Table 3. Summary of Studies on Infectious Diseases Outcomes Among Children in Haiti (continued)

Time	Location	Outcome	Citation
February - May 2013	4 sites (Communes of Gressier and Jacmel, Ouest and Sud-Est Departments, Haiti)	Antibody response increased with age with 6/61 (9.8%) of 2 to 5-year-olds testing positive for both antibodies, 35/190 (18.4%) of 6 to 9-year-olds testing positive for both antibodies, 58/216 (26.9%) of 9 to 13-year-olds testing positive for both antibodies, and finally 46/154 (29.9%) of 14 to 17-year-olds testing positive for both antibodies	Fricken et al, 2014 ²⁰
Wound and Skin Infections			
10 days following earthquake	Israeli field hospital (Port-au-Prince, Haiti)	5 out of 272 patients (1.8%) had skin infections	Farfel et al, 2014 ⁷
January - February 2010	Fort de France University Hospital (Martinique)	44 of 85 (52.0%) wounds cultured positive with the following profile: nonfermenting Gram-negative bacilli (19), Enterobacteriaceae (18), Gram-positive cocci (24), and Candida (5); 21 initial samples from 10 patients were polymicrobial; 5 isolates were pan-drug resistant - 2 MRSA and 3 ESBL	Arquès et al, 2013 ³⁹
2012-2013 academic year	Christianville private school clinics (Gressier/Leogane region of Haiti)	In kindergarten, 43 of 286 (15.0%) and in primary school, 64 of 591 (11.0%) had skin infections	Beau De Rochars et al, 2015 ⁴
Miscellaneous			
Weeks 3 - 31 after earthquake	16 different MSF clinics (Dufort, Jacmel, Leogane, and Port-au-Prince, Haiti)	11 patients with jaundice, 2 with tetanus, 4 with suspected measles, 11 with suspected meningitis, 1 with suspected diphtheria, 8,734 unclassified cases	Polonsky et al, 2013 ⁸
November 2010 - May 2011	18 primary care clinics (Leogane and Magandou, Haiti)	73.0% of the patients in Leogane and 57.1% of the patients in Magandou diagnosed with a general infectious disease	Dickstein et al, 2014 ¹¹
June - July 2013	Corail, Grande Anse, Haiti	7.0% of females and 0.0% of males tested positive for mansonella ozzardi parasite	Raccurt et al, 2014 ²¹
May 2014 - February 2015	School clinic (Gressier/Leogae regions in Haiti)	3 of 177 (1.7%) children tested positive for Zika virus	Lednický et al, 2016 ²²

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Table 3 (continued). Summary of Studies on Infectious Diseases Outcomes Among Children in Haiti

Abbreviations: MSF, Médecins Sans Frontières; HUP, Hôpital Universitaire La Paix located in Port-au-Prince; , Hôpital Foyer Saint Camille located in Port-au-Prince; HSN, Hôpital Saint Nicolas (HSN) de Saint Marc located in Artibonite Department; SMJ, Hôpital Saint Michel de Jacmel located in Southeast Department; HUEH, Hôpital de l'Université de l'Etat d'Haiti located in Port-au-Prince; HSD, Hôpital Saint Damien located in Port-au-Prince; GHESKIO, The Haitian Group for the Study of Kaposi's Sarcoma and Opportunistic Infections; CTC, Cholera Treatment Center; ORP, Oral Rehydration Point; URTIs, upper respiratory tract infections; LTRIs, lower respiratory tract infections; RTIs, respiratory tract infections; MRSA, methicillin-resistant Staph. Aureus; ESBL, extended-spectrum betalactamase.