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Epidemiological Study on Acute Diarrheal Outbreak Reported in Albaida Municipality After Danial Storm

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دراسة وبائية حول تفشي الإسهال الحاد المُبلَغ عنه في بلدية البيضاء بعد عاصفة دانيال

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Abstract:
Background: The health impacts of floods lead to an increase in mortality and morbidity rates, primarily due to diseases such as diarrhea.
Aim: To analyze the incidence of diarrheal diseases in "Albaida City" after the occurrence of Danial Storm.
Method: A descriptive observational design to investigate the epidemiological disease burden and determinants of diarrheal disease in Albayda city, Libya, focusing on cases reported following the Danial Storm. The study conducted a comparative analysis of diarrheal cases and associated mortality recorded over four consecutive months post-flood, from September 2023 to December 2023.
Results and discussions: The study reported a significant temporal association between the Danial Storm and the subsequent outbreak of diarrheal disease in the city. The increase in cases in the fourth-week period post-storm was clear. Many reasons describe the increase in diarrhea cases after the Danial Storm, such as the disruption and poor sanitation infrastructure. This caused contamination of water sources in the area. The secondary transmission wave, peaking in November despite the storm's immediate effects subsiding, underscores the importance of sustained public health interventions. The data recorded two deaths of children under five. This highlights the critical need for increased awareness regarding the risks of using contaminated groundwater. While the outbreak was eventually controlled, likely due to interventions, such as clean water provision and awareness campaigns, the persistence of contaminated wells emphasizes the ongoing vulnerability of the region. The high percentage of contaminated wells (53%) indicates a pressing need for continued comprehensive solutions to ensure safe water access for the affected population.
Conclusion: The study contributed valuable insights to the field of public health, informing future disaster response strategies and highlighting the urgent need for sustainable solutions in Libya to protect vulnerable populations from waterborne diseases.

Keywords: Danial Storm, Eastern Libya, Diarrhea Outbreaks, Incidence Rate.

الملخص.
الخلفية: تؤدي الآثار الصحية للفيضانات إلى زيادة معدلات الوفيات والمرض، ويرجع ذلك بشكل رئيسي إلى انتشار الأمراض مثل الإسهال.
الهدف: هو دراسة معدل حدوث الاسهال في "مدينة البيضاء" بعد إعصار دانيال.
الطريقة: دراسة وصفية لملاحظة الانتشار الوبائي للاسهالات في مدينة البيضاء، ليبيا، مع التركيز على الحالات المبلغ عنها بعد إعصار دانيال. أجرت هذه الدراسة تحليلاً مقارنًا لحالات الإسهال والوفيات المرتبطة بها، التي سُجلت على مدى أربعة أشهر متتالية بعد الفيضانات الناتجة عن إعصار دانيال، من سبتمبر 2023 إلى ديسمبر 2023.
النتائج والمناقشات: أظهرت الدراسة ارتباطًا زمنيًا كبيرًا بين إعصار دانيال والتفشي اللاحق للأمراض الإسهالية في المدينة. وكان الارتفاع في الحالات واضحًا خلال فترة الاسابيع الأربعة التي تلت العاصفة. وتُعزى هذه الزيادة في حالات الإسهالات إلى عدة أسباب: منها ضعف البنية التحتية للصرف الصحي وسوء حالتها، مما أدى إلى تلوث مصادر المياه في المنطقة. كما أن موجة العدوي الثانوية، التي بلغت ذروتها في نوفمبر على الرغم من تراجع التأثيرات المباشرة للعاصفة، تؤكد ضعف بنيه وتوزيع شبكة الصرف الصحي للمدينة، حيث سجلت البيانات حالتين من وفيات الاطفال دون سن الخامسة، مما يبرز الحاجة الملحة لزيادة الوعي بمخاطر استخدام المياه الجوفية الملوثة. ورغم السيطرة في النهاية على تفشي الاسهالات بفضل التدخلات كتوفير المياه النظيفة وحملات التوعية في فتره الفيضان، إلا أن تلوث الآبار لا يزال مستمرًا، وهذا يشير إلى الضعف في البنيه

التحتية للمنطقة حيث تشير الاحصائيات ان نسبة الآبار الملوثة حينها وصلت الي (53%) والتي تستدعي إلى الحاجة الملحة لحلول شاملة ومستمرة لضمان الوصول إلى مياه آمنة للسكان المتضررين.
الخلاصة: قدمت الدراسة رؤى قيمة في مجال الصحة العامة، تسهم في توجيه استراتيجيات الاستجابة للكوارث في المستقبل وتسليط الضوء على الحاجة العاجلة لحلول مستدامة في ليبيا لحماية الفئات الضعيفة من الأمراض المنقولة بالمياه.

الكلمات المفتاحية: إعصار دانيال، شرق ليبيا، فاشيات الاسهالات، معدل الحدوث.

Introduction

Natural disasters result in population displacement, infrastructure destruction, economic setbacks, loss of life and injuries, and elevate the likelihood of infectious disease outbreaks. In 2018, natural disasters impacted 61.7 million individuals globally, resulting in 10,373 fatalities and billions of US dollars in damages. There seems to be a declining trend in total mortality linked to natural disasters over the long run [(1),] Reporting accurate data from such events faces numerous technical and political hurdles. Additionally, the complexity of these disasters is on the rise, driven by factors like climate change, population migration, economic interconnectedness, and globalization. [(5)]

Floods stand out as the most common natural calamity, impacting over 2.8 billion individuals in the past three decades alone, [(2)] and claiming the lives of over 200,000. Over recent years, their occurrence has shown a tendency to escalate, a trend expected to exacerbate further due to climate change. [(3,4)]

The health impacts of floods are intricate and widespread, potentially leading to increased rates of mortality and morbidity, particularly from diarrheal diseases [(6,7).] Diarrhea, encompassing both infectious (bacteria, parasites, viruses) and non-infectious (food intolerances, intestinal diseases) forms, remains a significant global public health concern. It accounts for an estimated 4.1% of the total disability-adjusted life years (DALYs) according to the Global Burden of Disease (GBD), with 1.8 million deaths annually attributed to it [(8).] Floods can compromise water quality through various means, such as contaminating surface or groundwater sources with stormwater runoff, and introducing fecal contaminants like bacteria, protozoa, and viruses. Additionally, cross-contamination may occur between sewage and water pipes, particularly in areas with outdated water infrastructure, and sewage may be released into local waterways due to overflows or bypasses [(9,10).]

One of the key messages from the collection is the importance of preparedness; anticipation and preemption are powerful interventions. Disaster preparedness is essential for health security for several reasons. Disasters and emergencies can heavily strain health infrastructure, including hospitals, clinics, and medical supply chains. By being prepared, communities can protect this infrastructure and ensure it functions during and after a disaster. Preparedness also allows emergency responders to provide timely responses, which is crucial in situations where every minute counts, such as during disasters. Another critical aspect is preventing disease outbreaks. Disasters can heighten the risk of disease outbreaks, especially in areas where sanitation and hygiene are compromised. Preparedness efforts help mitigate this risk by ensuring access to clean water, adequate sanitation facilities, and proper medical care. Additionally, being prepared for infectious disease outbreaks that can complicate response measures like sheltering and evacuation is vital [(34).]

The primary aim of this research is to analyze the prevalence of diarrheal diseases in Albaida after the occurrence of Danial Storm. This study seeks to understand the impact of natural disasters, specifically the Danial Storm and floods, on public health, with a focus on diarrheal diseases.

Eight studies have detailed cascading risk pathways for outbreaks following flooding events. Among these, four studies specifically reported outbreaks of leptospirosis. In Bulgaria, exceptionally heavy rainfall in September 2014 led to an increase in leptospirosis cases, rising from 12 cases in 2010 to 20 in 2014 [(26).] Similarly, in Germany, heavy rains triggered a leptospirosis outbreak among a group of strawberry pickers [(24),] resulting in 13 hospitalizations and approximately 20% of the group showing symptoms of the disease. In Austria, a triathlon event led to four hospitalizations due to leptospirosis exposure, with one individual requiring haemodialysis for kidney failure[(25).]In France, three leptospirosis cases were reported following heavy rain during a refuse collector strike, which left uncollected rubbish in urban areas and attracted rodents[(27).]In Germany, heavy rainfall caused contamination of river water and recreational areas, leading to an outbreak of 24 cases of Cryptosporidium hominis, significantly higher than the usual annual average of 9 cases[(28).] In Denmark, severe rainfall overwhelmed the sewage system, causing seawater contamination with sewage. This resulted in an outbreak of diarrhea and vomiting among triathlon participants, caused by E. coli, Campylobacter jejuni, and Giardia lamblia [(29).] In that year, 42% of triathlon participants reported gastrointestinal symptoms, compared to only 8% in the following year's event. Notably, in Austria's leptospirosis outbreak, triathlon participants were affected after swimming in a contaminated lake rather than seawater [(25).]

Material and methods

Study Design

This study employs a descriptive observational design to investigate the epidemiological disease burden and determinants of diarrheal disease in Albaida city, Libya, specifically focusing on cases reported following the Danial Storm. Utilizing data collected from healthcare facilities and public health records, we conducted a

comparative analysis of diarrheal cases and associated mortality recorded over four consecutive months post-flood.

Source of Data
The primary data for this research was sourced from the National Centre for Disease Control (NCDC) in Libya, which provided a reliable dataset critical for investigating the epidemiological disease burden and health outcomes of interest.

Data collection
The data selected spans from the onset of the Daniel Storm in September 2023 to December 2023, capturing the public health impacts in eastern Libya in Albaida city.

Population and Sample

The study population includes all reported cases of diarrhea disease in Albaida City during the specified period.

Inclusion Criteria
Encompass all age groups and, however, the total number of cases may not correspond to the total age in some cases due to the lack of details, ensuring a comprehensive assessment of the outbreak. the study also included all cases that were diagnosed with acute diarrheal and were reported to the NCDC.

Exclusion Criteria
Involve cases with other diseases in the report that is monitored by the NCDC in Libya.

Statistical analysis
Data were analyzed by GraphPad Prism 9.0 (GraphPad, La Jolla, CA). Data are presented as mean values ± SEM, and statistical significance was determined using the two-way analysis of variance (ANOVA; ordinary) with Sidak's multiple comparisons test when comparing multiple unmatched groups with more than one grouping variable (*P < 0.05, **P < 0.01, ***P < 0.001, and ****P < 0.0001). For experiments where a non-parametric test was required to analyze repeated measures with missing values, significance was determined by Friedman's test and p values represent pairwise comparisons of adjusted p values using the Wilcoxon test. Statistical significance was considered when: $*P \leq 0.05$.

Results and discussion

Results
The data collected from the NCDC outlined the daily reported cases of diarrhea over four months, from September to December 2023. In this project, the data was recorded every week for each month, including the number of deaths **(Table 1).** The reported data revealed no significant differences in the monthly death tolls. However, there was one death reported in October and one death in November. Regarding the total reported diarrhea cases, November exhibited a significantly higher number of cases compared to the other three months **(Figure 1).** It is also worth noticing the significant decline in cases reported in December.

Table 1 The epidemiological data of diarrheal cases and related deaths in the four months after Danial Storm.

Month	Weeks	cases	% Deaths
September	week 2	13	0
	week 3	15	0
	week 4	105	0
October	week 1	502	0
	week 2	442	0
	week 3	287	0
	week 4	911	1
November	week 1	928	1
	week 2	949	0
	week 3	748	0
	week 4	701	0
December	week 1	323	0
	week 2	98	0
	week 3	149	0
	week 4	161	0
Total		6332	0.032%

Analysis Method	Description	Significance Levels
Software Used	GraphPad Prism 9.0 (GraphPad, La Jolla, CA)	-
Data Presentation	Mean values ± SEM	-
Statistical Significance	Determined using two-way ANOVA (ordinary) with Sidak's multiple comparisons test	-
P-value thresholds	*P < 0.05, **P < 0.01, ***P < 0.001, and ****P < 0.0001	-
Non-parametric Test	Friedman's test for repeated measures with missing values	-
Pairwise Comparisons	Wilcoxon test with adjusted p values	-
Overall Significance	Considered significant when *P ≤ 0.05	-
One-way ANOVA	With multiple comparisons	*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Table 2 Incidence Rate = (Total population at risk during the same time point period number of new cases during a specific time period) x Multiplier.

Month	Weeks	cases	Incidence rate100.000
Sep	week 2	13	5.2
	week 3	15	6
	week 4	105	42
Oct	week 1	502	200.8
	week 2	442	176.8
	week 3	287	114.8
	week 4	911	364.4
Nov	week 1	928	371.2
	week 2	949	379.6
	week 3	748	299.2
	week 4	701	280.4
Dec	week 1	323	129.2
	week 2	98	39.2
	week 3	149	59.6
	week 4	161	64.4
Total		**6332**	**0.032%**

- Number of new cases in week one = 13
- Total population at risk = 250,000
- A common multiplier is 100,000 to express the incidence rate per 100,000 people.

Incidence Rate $/\frac{\mathbf{13}}{\mathbf{250.000}}$×100.000=5.2

Therefore, the incidence rate of diarrhea in week one is 5.2 cases per 100,000 people

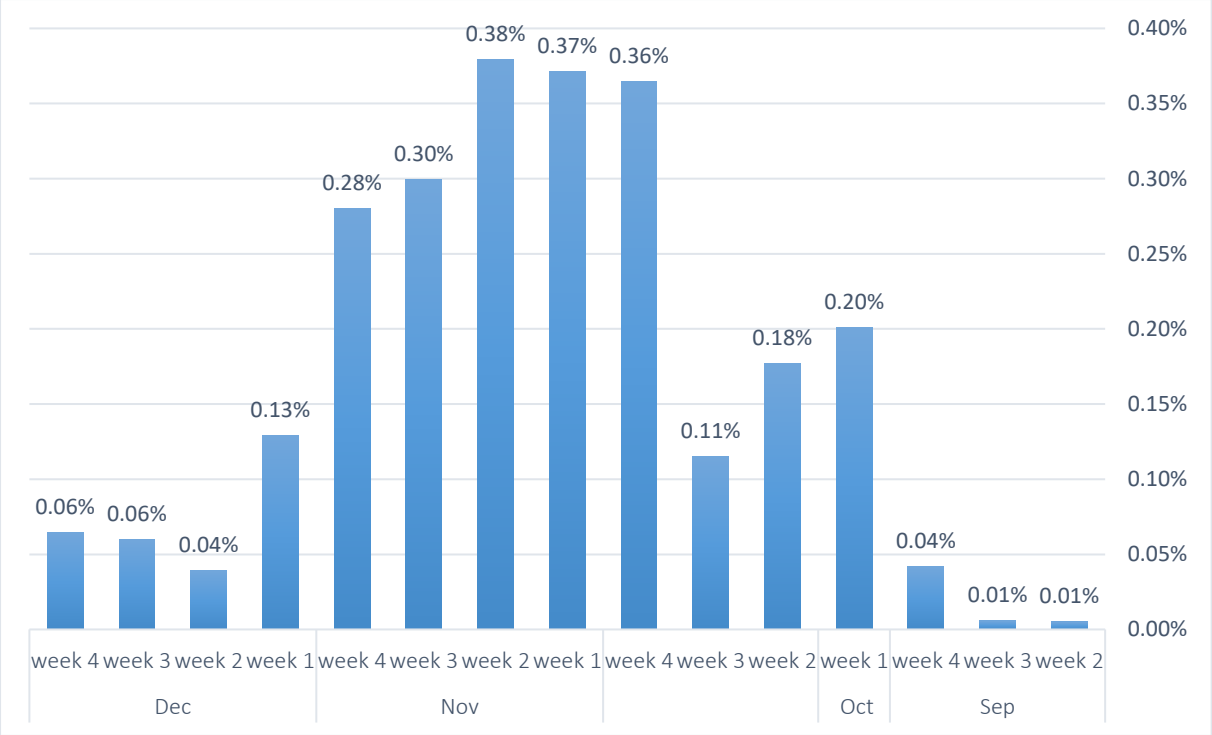

Figure 2 Monthly patterns of diarrhea cases in Albaida Municipality from September to December 2023(Incidence Rate*)*.

In September, the cases were relatively low, starting at 13 in week 1 and increasing slightly to 105 by week 4.In October saw a significant increase, peaking at 911 cases in week 3 before dropping to 287 in week 4. In November, the number of cases remained high but fluctuated, reaching a maximum of 928 in week 2 and ending with 701 in week 4. In December showed a declining trend, with cases decreasing from 323 in week 1 to 161 by week 4.

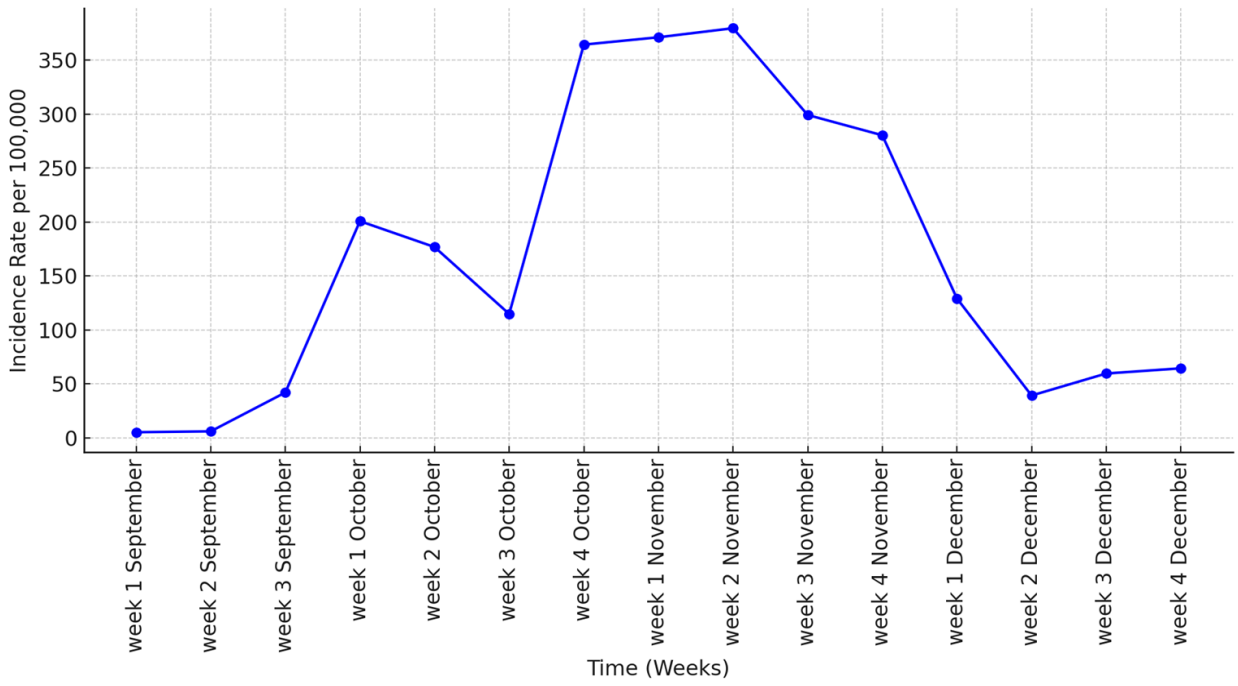

Figure 3 Epidemiological curve according to epidemic weeks from September to December 2023.

In September the number of cases starts low but increases significantly by the third week. Incidence rates follow a similar pattern, starting at a low value and increasing by the third week with an Average Incidence Rate per 100,000 = 17.73. In **October** there is a sharp increase in both cases and incidence rates in the first week. The highest number of cases and incidence rates are observed in October, particularly in the first and fourth weeks. The number of cases and incidence rates fluctuate but generally remain high throughout the month with an Average Incidence Rate per 100,000 = 214.20. In November the number of cases and incidence rates continue to be high in the first two weeks. A gradual decline in both cases and incidence rates is observed in the latter part of the month with an Average Incidence Rate per 100,000 = 332.60. In December there is a significant drop in cases and incidence rates compared to the previous months. The number of cases and incidence rates remain relatively low and stable throughout the month with an Average Incidence Rate per 100,000 = 73.10.

5. Discussion

In this study the temporal association between floods related to Storm Danial and the subsequent outbreak of diarrheal disease, as illustrated in Table 1, suggests a potential causal relationship. The relatively low incidence of cases in September, followed by a dramatic surge in October after 4 weeks the numbers increasing. This is the same result of the previous study that was mentioned, and this is a positive confirmation of the increase in the number of diarrhea cases four weeks after the flood [32]. in Figuer-1, in September the number of cases reported is minimal, almost negligible in comparison to the subsequent months. This low number may suggest that the floods after Danial Storm's immediate impact were not fully realized or recorded in this month with p-value: *p<0.05. In October a significant increase in the number of cases is observed in October, with cases rising sharply to a mean value slightly below 2000. This spike could indicate the initial phase of impact and reporting following the floods, possibly due to delayed responses or the gradual emergence of storm-related health issues. In November the number of cases further escalates, peaking at a mean value just below 4000. This marked increase is statistically significant when compared to both September and October (****P < 0.0001). The surge in cases during November suggests a period where the storm's full effects were most acutely felt, leading to higher reporting of health-related issues. In December there is a noticeable decline in the number of cases, dropping to around 1500. Although this number is significantly lower than that of November.

(**P < 0.01), it remains higher than the cases reported in October (**P < 0.01) and September (**P < 0.05). The decline could be attributed to effective response measures, recovery efforts, or a natural reduction in storm-related health impacts over time.

flood can disrupt sanitation infrastructure, leading to contamination of water sources, local water providers have reported that 28 out of 220 boreholes in the municipality need repairs, and an additional 41 boreholes are working but producing contaminated water [33]. The water pipe that connects the Sousa desalination plant with Albaida has also been damaged over a 60-meter stretch, this caused an increase in the number of diarrheal cases and the transition to the second wave. The peak in cases observed in November, even after the storm's immediate effects had subsided, suggests a possible secondary transmission wave with two deaths under the age of five years, according to the report from (The National Center for Disease Control in Libya) due to lack of awareness of the need to avoid using groundwater for drinking and washing. The decline in cases in December, however, indicates that the outbreak was eventually brought under control, likely due to providing clean water and intensive awareness campaigns for residents in affected areas. However, the use of groundwater remains a significant risk, as confirmed by tests conducted by the Environmental Sanitation Department in Al-Bayda. These tests revealed that approximately 53% of the 77 wells tested are contaminated.

5.1 Limitations of the study

The study has several limitations, first There is no clear data on the ages of cases affected by diarrhea. Secondly, the living conditions of the affected families to confront these diseases resulting from the flood.

Conclusion

This study unequivocally demonstrates the direct link between the floods related to Danial Storm and the subsequent diarrheal disease outbreak. The delayed surge in cases, consistent with previous findings, confirms the flood's role in triggering the crisis through widespread water contamination. The extensive damage to vital infrastructure, such as boreholes and the Albaida water pipe, compounded the issue, leading to a secondary transmission wave with tragic consequences. The successful containment of the outbreak underscores the effectiveness of swift public health interventions, including the provision of clean water and awareness campaigns. However, the persistent contamination of over half of the tested wells reveals a lingering threat to public health. This necessitates continued comprehensive measures to ensure access to safe water sources for the long term. This research serves as a compelling reminder of the vulnerability of communities to waterborne diseases following natural disasters. It highlights the critical importance of robust

infrastructure, preparedness, and timely public health interventions in mitigating such outbreaks. Furthermore, it emphasizes the need for ongoing monitoring of water quality and sustained educational efforts to promote safe water practices, especially in regions prone to extreme weather events.

Ultimately, this study contributes valuable insights to the field of public health, informing future disaster response strategies and highlighting the urgent need for sustainable solutions to protect vulnerable populations from waterborne diseases.

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