Prevalence and Trends of Diarrhoea in Children Under Five in Masiphumelele, Cape Town, South Africa (2019-2023)

By

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Title: Prevalence and Trends of Diarrhoea in Children Under Five at Masiphumelele, Cape Town, South Africa (2019-2023)

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Abstract

Background:

Diarrhoea in children under five years is a major cause of morbidity and mortality in SubSaharan Africa. Informal settlements are disproportionately affected due to overcrowding, inadequate sanitation, and unsafe water practices. This study provides a comprehensive analysis of diarrhoea prevalence, demographic distribution, seasonal patterns, and the effect of the COVID-19 pandemic on paediatric diarrhoea cases in Masiphumelele Township, Cape Town, South Africa (2019–2023).

Method:

A retrospective observational analysis of clinical records from January 2019 to December 2023 at Masiphumelele Clinic was conducted. The prevalence of diarrhoea was calculated using various denominators, including the total clinic patients, the total children under five years of age, and the total number of clinic patients with diarrhoea. Statistical analyses evaluated trends using proportion comparisons (Z-tests) and temporal patterns (Chi-squared tests for trends) evaluate significant changes in prevalence over time and during the COVID19 period.

Results:

Diarrhoea in children under five years of age accounted for 2.04% of the total 391355 clinic visits, with the trend rising from 79 cases in 2019 to 233 in 2023. Children under five years of age accounted for 11.2% of all clinic patients and 74.7% of cases of diarrhoea. The highest burden was observed among boys (56%) and children between 2 and 3 years (28.2%). Seasonal peaks in diarrhoea prevalence were observed in the warmer months, with the highest case counts recorded in February (11.7%) and November (10.2%), which is consistent with the known diarrhoeal disease seasonality in South Africa. The prevalence of diarrhoea increased significantly from 1.37 cases per 1000 before the COVID-19 pandemic to 2.51 cases per 1000 after the pandemic ($p < 0.001$). This increase may reflect healthcare disruptions, limited access to prevention services, and changes in hygiene practices during the pandemic.

Conclusions:

This study highlights the continued burden of diarrhoeal diseases on informal settlements and the worsening role of the COVID-19 pandemic. Targeted interventions that focus on improving

water and sanitation infrastructure, seasonal preparation, and educational campaigns that focus on age-specific vulnerabilities are essential. Strengthening public health policies and health systems that address seasonal disease patterns and vulnerabilities is critical to mitigate the effects of diarrhoea and ensure resilience to future public health crises.

Keywords:

Childhood diarrhoea, Under-five, Diarrhoea prevalence in SA, Seasonality of diarrhoea, Diarrhoea in Cape Town informal settlement.

Background

Diarrhoea is the third most common cause of death among children under five years of age globally and results in approximately 443,832 deaths annually [1]. Children in Sub-Saharan Africa experience an average of three diarrhoea events per year [2]. In South Africa, diarrhoea is the third most common cause of death among children under five years of age, contributing to 16% of mortality and 8.8% of disability-adjusted life years (DALYs) lost [3,4]. Although diarrhoea in children is a significant burden in South Africa, long-term trends in informal settlements have been investigated to a limited extent as existing studies often rely on cross-sectional data with seasonal biases [5, 6].

The economic and social effects of childhood diarrhoea further exacerbate the burden. Direct healthcare costs per episode range from $4.30 for outpatient care to $85.85 for hospitalizations and therefore, presents a substantial financial burden for low-income households [7]. Diarrhoeal disease also contributes to childhood stunting, malnutrition, and long-term developmental delays [8]. These outcomes emphasize the necessity of context-specific research to inform interventions to reduce the prevalence of diarrhoea among children and the associated inequalities in vulnerable informal settlements.

In South Africa, inadequate access to clean water, basic sanitation and good hygiene practices increases the risk of diarrhoea [9]. While the nation-wide supply of sanitation facilities has improved, informal settlements in cities face challenges such as overcrowded living conditions, poorly maintained water and sanitation facilities that are often shared, and lack of waste disposal which increase the risk of contamination and transmission of infectious diseases [9,10,11,12]. Persistent structural inequalities, many of which stem from Apartheid era service disparities,

contribute to an increased diarrhoea burden in marginalized communities. Limited access to piped water, inadequate sanitation, and high population densities in informal settlements create conditions favourable for frequent diarrhoea outbreaks [6, 13].

Post-apartheid urbanisation in South Africa has intensified the challenges of service delivery, particularly in informal settlements. Rapid population growth in urban areas, driven by migration and housing backlogs, has placed considerable strain on basic infrastructure and public health systems. Weimann and Oni (2019) noted that access to adequate water and sanitation remains essential for controlling infectious diseases in urbanising contexts [14]. Currently, approximately 66% of South Africa's population resides in urban areas [3]. This demographic shift places a growing burden on municipalities to provide equitable water, sanitation, and healthcare services, often resulting in infrastructure deficits that disproportionately affect informal settlements.

The COVID-19 pandemic exacerbated these challenges by disrupting maternal and child healthcare services and straining infrastructure in informal settlements [15,16]. While heightened hygiene measures may have initially reduced the incidence of diarrhoea in countries such as Ethiopia, Bangladesh; other areas, including parts of Cape Town, saw increased hospital admissions for diarrhoea during the pandemic [17,18,19].

Understanding trends in childhood diarrhoea requires epidemiological designs that capture temporal variability and population-specific burdens. Previous research in Sub-Saharan Africa has employed a variety of methods, including cross-sectional surveys, cohort studies, and analyses of routinely collected health data. While large-scale studies such as Global Enteric Multicenter Study (GEMS) [20] and Etiology, Risk Factors, and Interactions of Enteric Infections and Malnutrition and the Consequences for Child Health (MAL-ED) [21] have provided insights into the etiology of diarrhoea in multicountry settings, they are resource-intensive and not always feasible at the local level [22,23]

Retrospective observational studies using routine health facility data have been increasingly used to monitor diarrhoea trends over time. For example, Tornheim et al. (2010) analysed inpatient records to assess diarrhoea-related hospitalisations in rural Kenya, revealing age-specific trends and seasonal variation [24]. Similarly, Rahmat et al. (2023) conducted a cross-sectional retrospective study in Karachi, Pakistan, which used clinic registers to assess antibiotic prescribing patterns in diarrhoeal disease [25]. In Cape Town, Nguyen et al. (2021) used a cross-

sectional design based on household surveys to estimate diarrhoea prevalence in informal settlements, but did not explore temporal trends [3].

While useful, cross-sectional studies fail to capture seasonal and pandemic-related changes, limiting their utility for intervention planning. In contrast, longitudinal clinic-based datasets allow for trend analysis, seasonality assessment, and demographic disaggregation. However, they are limited by the absence of individual-level behavioural and environmental exposures. The present study draws on the strengths of routine clinic data, in line with these previous approaches, to estimate the burden and temporal patterns of diarrhoea among children under five in a South African informal settlement.

While previous studies have examined childhood diarrhoea prevalence in South African informal settlements, most have relied on cross-sectional designs with limited ability to assess temporal trends or the effects of external disruptions, such as pandemics or climate variability [3, 5, 13]. There is an urgent necessity of longitudinal data and local-level epidemiology, particularly in informal settlements, to assess disease patterns and support decision-making and prioritization for public health interventions, as these settlements experience disease burden differently [24]. Therefore, this study aims to address these gaps in understanding diarrhoea among children under five in informal settlements, by using longitudinal clinic data (2019–2023), to examine trends, seasonal patterns, and the impact of the COVID-19 pandemic on childhood diarrhoea in an informal settlement context.

Methods

Study design

A retrospective observational study was conducted to examine clinical records from Masiphumelele Clinic. The medical records were obtained from the City of Cape Town Municipality, City Health Department, for the period from January 1, 2019, to December 31, 2023. The objective was to assess the prevalence of diarrhoea among children under five years of age, assess temporal trends and assess the impact of COVID-19 on diarrhoeal prevalence [26].

This is a retrospective observational study using longitudinal clinic data collected over a five-year period. Although not a cohort study, the term 'longitudinal' refers to the temporal scope of the dataset rather than to repeated follow-up of the same individuals.

Study area

Masiphumelele Township is located in the Cape Town metropolitan, South Africa, situated between Kommetjie, Capri Village and Noordhoek. Originally called Site 5, the area was renamed “Masiphumelele” (which is a Xhosa word meaning “let us succeed”) by its residents. The community consists of a mix of formal, planned settlements and informal settlements, which is divided into sections (Section A-E, Section Z, School Site, Kolobe and Amakhayangoku). Since its establishment in the 1980s with an initial population of 400-500 people, the township has grown to approximately 50 000 residents across 23 000 households [27]. According to the latest 2011 Census, 72.9% of households are informal dwellings, 73% of households have access to piped water in their dwelling or inside their yard, of which 20.5% of households have access to piped water inside the dwelling and 90% of households have access to flushing toilets. The area’s total population comprises of 53% males and 47% females and the percentage distribution of the population by age group is as follows: 0-4 years (12.3%), 5-19 (20.4%), 20-59 (62.4%) and 60-85+ (6.5%) [28].

Study population, inclusion and sampling

This study focused on children under five years old who were diagnosed with diarrhoea at Masiphumelele Clinic, a primary healthcare facility within the South Peninsula Health District in Cape Town. Clinical records from January 1, 2019, to December 31, 2023, were reviewed. The study included all children aged 0–5 years with clinician-diagnosed diarrhoea at Masiphumelele Clinic between 2019 and 2023. Cases were recorded based on clinical assessments, without microbiological confirmation. Since children who were treated outside the clinic (e.g., private facilities or home-based care) were not captured in the dataset, there may be potential selection bias. The site and study population were selected based on the township’s challenging living conditions, limited access to services, and the documented burden of diarrhoeal diseases in similar settings [3].

The study included all clinic visit records for children aged 0 to 59 months (under five years) who had a documented clinical diagnosis of diarrhoea between 1 January 2019 and 31 December 2023 at Masiphumelele Clinic. To calculate prevalence, the total number of clinic visits during the same period, regardless of the patient’s age, diagnosis, or reason for visit, was used as the

denominator. Only records with complete data for age, sex, and diagnosis were included in the analysis. Records were excluded if the child was older than 59 months at the time of the clinic visit, if the diagnosis of diarrhoea was missing or not clearly defined, or if key information such as age or diagnosis was incomplete.

No sampling technique or sample size calculation was applied, as the study used a complete dataset of all clinic admissions from 2019 to 2023. The total dataset included 391,355 records, representing a census of clinic visits within the specified period.

Data source and variables

Secondary data were extracted from anonymized clinic records for Masiphumelele clinic within the Patient Record and Health Information System (PREHMIS), which is managed by the City of Cape Town Metropolitan Municipality. All primary health care facilities in the City of Cape Town store routine patient information and encounters electronically on PREHMIS. During each patient encounter a primary health facility in the City of Cape Town, a series of barcodes are scanned to record the diagnosis and services provided during that visit [30]. The dataset was anonymised by the City Health Department before being accessed by the researcher. Only the clinic identifier (Masiphumelele) was retained; no patient names, addresses, or geospatial identifiers were included.

The records included the patient's identification number, the date of admission to the facility, the type of service provided, the extent of their condition, the patient's date of birth, sex, and age. The data obtained from the clinical records included the total number of admissions (all ages), the total number of cases of diarrhoea (all ages), and the total number of cases of diarrhoea among children under 5 years of age. Age groups were categorised into yearly intervals (e.g., 0–11 months, 12–23 months, 24–35 months, etc.) and sex (male and female) based on the available format of the clinic dataset, which reported child age in completed months or years. This approach ensured consistency with the data structure and allowed for l stratification of diarrhoea prevalence across early childhood developmental stages. This categorisation also aligns with local precedent, such as the study by Nguyen et al. (2021), which used similar age bands to analyse diarrhoeal disease risk among children under five in informal settlements in Cape Town [3].

Although not directly harmonised with the age groups used in multicountry studies such as GEMS, the grouping applied in this study supports locally relevant analysis [31]. Future studies may include standardised age groupings to facilitate cross-study comparability. Due to the anonymized nature of the data, it was not possible to consider repeat admissions among children under five years of age. Therefore, each admission was considered as an independent clinical episode in the analysis. A total of 391 355 admissions and 797 cases of diarrhoea among children under five years of age were analysed.

Statistical analysis

Descriptive statistics were used to summarize the prevalence and distribution of diarrhoea by seasons, age groups, and sex. Proportions, means and 95% confidence intervals (CIs) summarized the prevalence of diarrhoea by season, age group, and sex. The chi-square (χ^2) test for independence was applied to assess whether significant associations existed between diarrhoea prevalence and categorical variables, including age group, sex, and seasonality. This test is widely used in epidemiological studies to determine whether observed proportions differ significantly from expected distributions under the assumption of independence. To compare diarrhoea prevalence between specific subgroups, Z-tests for equality of proportions were used. These tests are appropriate for large samples and allow for statistical inference when comparing two independent proportions [32], such as the prevalence of diarrhoea among male children vs. female children or pre-COVID-19 vs. post-COVID-19 periods.

These periods were (i) before COVID-19 (January 01, 2019, to March 21, 2020) (ii) during COVID-19 (March 22, 2020, to June 22, 2022), and (iii) after COVID-19 (June 2022, 23 to December 31, 2023) time periods. These timeframes were based on the national lockdown period in South Africa with various levels of societal restrictions from 22 March 2020 to 22 June 2022 [33]. Given the study's focus on categorical comparisons, these statistical methods were chosen to provide robust, well-established techniques for analysing disease prevalence in population-based health research. The prevalence of diarrhoea was expressed as cases per 1,000 individuals at risk, and 95% confidence intervals (CIs) were calculated to quantify the uncertainty around these estimates. Statistical significance was set at $p<0.05$, and all analyses were conducted using R version 4.4.1 [34].

Ethical considerations

Ethical approval was obtained from the University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee (HREC) (Reference number: 568/2024) and institutional ethical approval and permission to access to the patient records from Masiphumelele Clinic was granted by the City of Cape Town, City Health Department (Reference number: 10969).

Results

This study examined the prevalence and characteristics of diarrhoea among children under five years of age in Masiphumelele Township and emphasised key demographic, seasonal, temporal, and COVID-19 trends.

Characteristics of Diarrhoea cases

From January 2019 to December 2023, Masiphumelele clinic recorded 391355 visits, with diarrhoea cases among children under five accounting for 2.04% (n=797) of all admissions. Of these cases, 56% were male and 44% were female suggesting a greater vulnerability among male children. The age distribution revealed that the highest prevalence was observed among children aged 2-3 years (28.2%) and 0 to 12 months (13.0%) ($p < 0.001$) had the lowest prevalence. Seasonal trends showed that the number of cases of diarrhoea peaked in February (11.7%) and November (10.2%) reflecting the patterns of diarrhoeal disease seasonality in South Africa (Table 1).

Table 1: Summary of characteristics among diarrhoea cases in children ≤5years

Characteristic	Summary statistic (N = 797)	*p-value
Month, n (%)		<0.001
January	71 (8.9)	
February	93 (11.7)	
March	86 (10.8)	
April	65 (8.2)	

May	70 (8.8)	
June	64 (8.0)	
July	39 (4.9)	
August	37 (4.6)	
September	55 (6.9)	
October	80 (10.0)	
November	81 (10.2)	
December	56 (7.0)	
Season, n (%)		<0.001
Summer	220 (27.6)	
Autumn	221 (27.7)	
Winter	140 (17.6)	
Spring	216 (27.1)	
Age (years), mean (sd)	3.18 (1.33)	
Age group, n (%)		<0.001
0 to ≤12 months	104 (13.0)	
>12 months to ≤2 years	134 (16.8)	
>2 years to ≤3 years	225 (28.2)	
>3 years to ≤ 4 years	168 (21.1)	
>4 years to ≤ 5 years	166 (20.8)	
Sex, n (%)		<0.001
Male	446 (56.0)	
Female	351 (44.0)	

*z-test for equality of proportions

Prevalence of Diarrhoea over Time

The overall prevalence of diarrhoea among children under five years of age was calculated at 2.04 cases per 1000 individuals at risk (95% CI: 1.90-2.18) (Table 2). Notably, there was a significant increase in prevalence during the study period, rising from 1.15 cases per 1000 in 2019 to 3.20 cases per 1000 in 2023 ($p < 0.001$), which indicates an increasing burden of diarrhoea over time (Table 2). Diarrhoea prevalence among children under five increased significantly over the study period, rising from 1.15 cases per 1,000 in 2019 to 3.20 cases per

1,000 in 2023 ($p < 0.001$). This trend is illustrated in Figure 1, which demonstrates a steady upward trajectory in cases, suggesting a worsening burden of disease over time.

Table 2: Diarrhoea Prevalence in Children ≤5 Years (2019–2023)

Year	Diarrhoea Cases (≤5y)	Total Clinic Pop.	Prev./1000 (Clinic Pop.)	Under-5 Pop.	Prev./1000 (Under-5s)	Total Diarrhoea Cases (All Ages)	Prev./1000 (of All Diarrhoea Cases)
2019	79	68958	1.15 (0.91–1.43)	7800	10.13 (8.03–12.61)	211	374.41 (308.92–443.48)
2020	97	67806	1.43 (1.16–1.74)	11329	8.56 (6.95–10.44)	148	655.41 (572.93–731.51)
2021	175	91287	1.92 (1.64–2.22)	17025	10.28 (8.82–11.91)	216	810.19 (751.43–860.21)
2022	213	90559	2.35 (2.05–2.69)	18519	11.50 (10.02–13.14)	244	872.95 (824.53–912.02)
2023	233	72745	3.20 (2.81–3.64)	16237	14.35 (12.58–16.30)	257	906.61 (864.24–939.25)
Overall	797	391355	2.04 (1.90–2.18)	70910	11.24 (10.48–12.04)	1076	740.71 (713.42–766.67)

Among children under five years of age (n=797), the prevalence of diarrhoea was significantly higher than in the general clinic population, at 11.24 cases per 1,000 individuals (95% CI: 10.48-12.04) and reaching 14.35 cases per 1,000 in 2023, up from 10.13 cases per 1,000 in 2019 (Table 2). This pattern highlights the increased disease burden specific to young children. (n=797).

Children under five years contributed disproportionately to the total diarrhoea, with 740.71 cases per 1,000 individuals (95% CI: 713.42–766.67). A marked increase was evident, rising from 374.41 cases per 1000 in 2019 to 906.61 cases per 1000 in 2023 ($p < 0.001$) (Table 2). This demonstrates that the proportion of diarrhoea among young children is increasing and highlights

the urgent necessity of targeted public health measures aimed at this vulnerable population group.

Impact of COVID-19 on diarrhoea prevalence

The COVID-19 pandemic had a significant impact on diarrhoea prevalence, among children under five years of age. Rates before the pandemic were at 1.37 cases per 1000 individuals (95% CI: 1.13-1.64.) rising to 2.04 cases per 1000 (95% CI: 1.84-2.25) during the pandemic and with further increase to 2.51 cases per 1000 (95% CI; 2.24-2.82) in the post-pandemic period ($p < 0.001$, Figure 1).

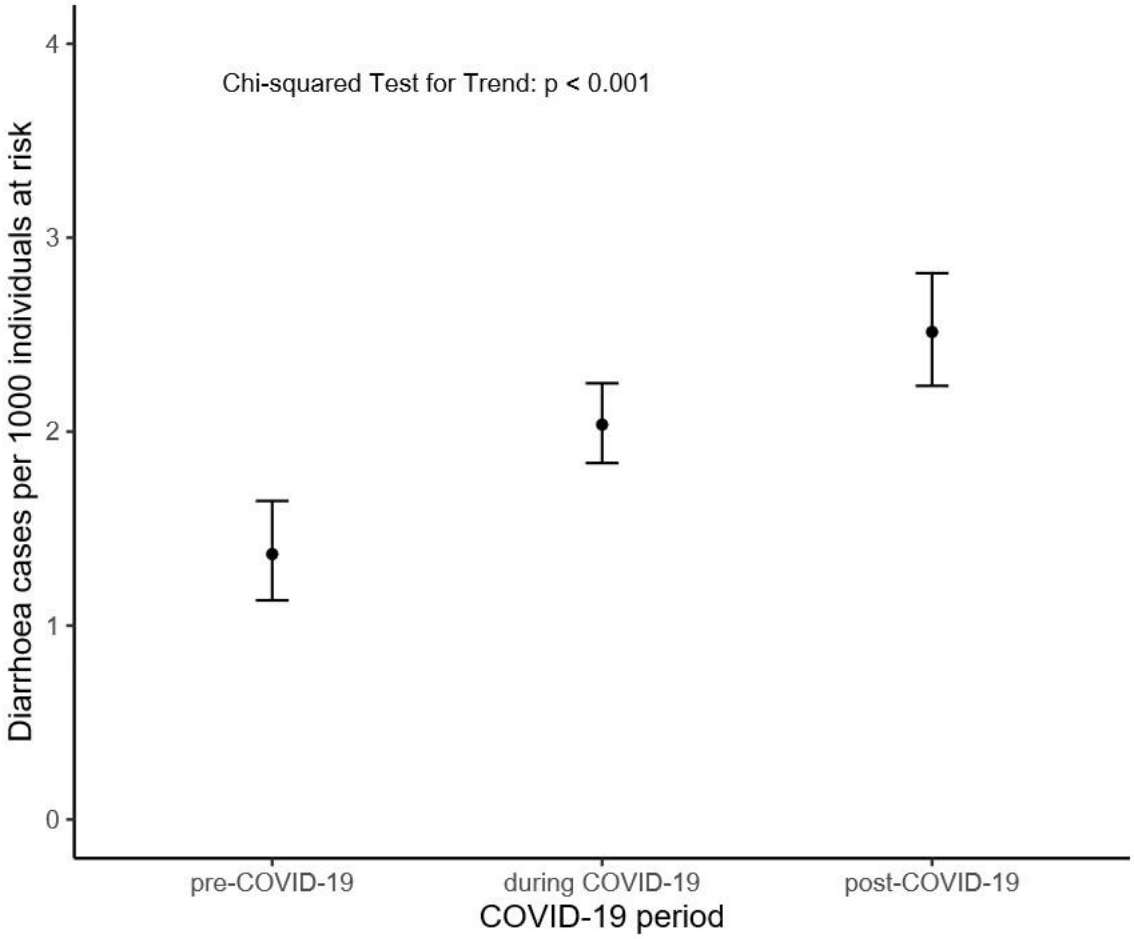

Figure 1: Prevalence of diarrhoea in children ≤5years during COVID-19 period out of total patients at risk.

When examining diarrhoea cases specifically among children under five, the proportion of young children affected increased sharply from 412.19 cases per 1,000 diarrhoea patients before

COVID-19 to 894.26 cases per 1,000 post-COVID-19 (Figure 2). Among children under five years of age as a proportion of clinic patients with diarrhoea, the prevalence before COVID-19 was at 412.19 cases per 1000 individuals (95% CI: 353.84-472.42) rising to 828.33 cases per 1000 (95% CI: 790.96-861.46) during COVID-19, and further increase to 894.26 cases per 1000 (95% CI: 856.02-925.24) post-COVID-19 ($p < 0.001$, Figure 2).

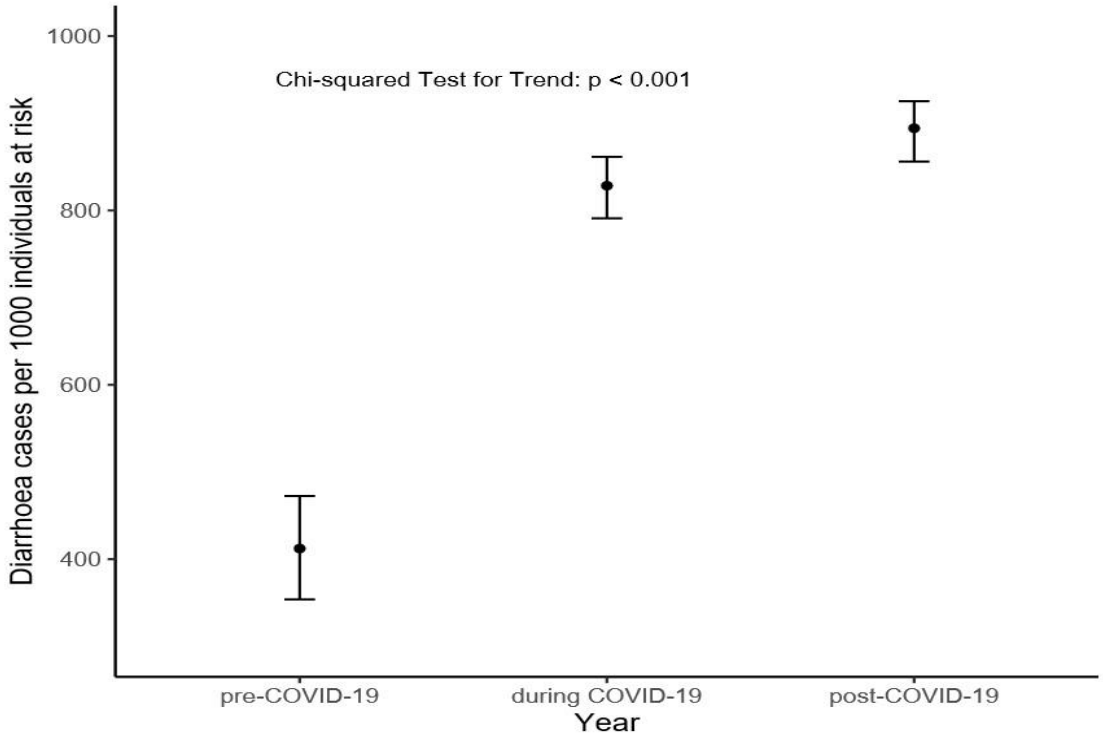

Figure 2: Prevalence of diarrhoea in children ≤5years during COVID-19 period out of total patients with diarrhoea.

These findings show that the significant increase in diarrhoea prevalence over time is a pressing public health concern. The COVID-19 pandemic has further exacerbated the burden of diarrhoea among children under five years of age in Masiphumelele.

Discussion

This study aimed to investigate the burden of U5D in informal settlements, with a focus on Masiphumelele in Cape Town. Prevalence rates, demographic trends, seasonal variations, and the effects of the COVID-19 pandemic on diarrhoea were examined.

From 2019 to 2023, there was an increase in diarrhoea prevalence that spanned various denominators, including the total number of clinic patients, children under five years of age, and clinic patients diagnosed with diarrhoea. In South Africa, the national prevalence of diarrhoea in children under five years of age is 13% [5]. This study recorded an overall prevalence of 1.12% for Masiphumelele over the time period, with the highest prevalence of 1.15% in 2022. An upward trend in diarrhoea cases among children under five indicates a growing burden of disease and signals potential deterioration in the underlying determinants of health, such as water quality, sanitation access, hygiene practices, and healthcare utilisation. For public health, this trend indicates that current prevention and control measures may be insufficient, and that environmental and infrastructural risks in the community remain unaddressed or have worsened over time. It also reflects increased vulnerability among young children in informal settlements, where systemic barriers often hinder effective disease mitigation [13, 20].

The observed seasonal peaks in diarrhoea among children under five years of age are consistent with trends in Sub-Saharan Africa and South Asia, where elevated temperatures in the warmer months contribute to higher transmission rates of pathogens [35]. In Masiphumelele, the highest prevalence was recorded in late summer, which corresponds with increased pathogen proliferation due to hot and dry weather conditions [36]. These trends are consistent with the Diarrhoeal Disease Season (DDS) in the Western Cape of South Africa, where warmer months between November and May contribute to the burden of diarrhoea [37]. These seasonal spikes may be driven by increased pathogen proliferation due to higher temperatures, greater exposure to contaminated water sources, and increased outdoor activities among young children during warmer months [37]. The observed seasonal peaks in diarrhoea in the warmer months make clear that seasonal preparedness initiatives are urgently needed, such as community education on hygiene practices and improving access to clean water during high-risk periods.

The focus of this study was on seasonal climatic factors as the primary explanatory framework for the observed trend in the higher number of diarrhoea cases reported in November. However, other contextual factors may also contribute. As noted by one of the examiners, November corresponds with the start of school recess in South Africa, when children spend more time at home. This change in routine could plausibly increase exposure to household-level risk factors, such as unsafe water storage or inadequate hand hygiene. Furthermore, during the COVID-19 pandemic, public health restrictions were often relaxed during this period, potentially increasing social interactions and exposure opportunities. While direct peer-reviewed evidence linking

school holidays to diarrhoeal transmission is limited, these contextual factors offer plausible complementary explanations and merit further investigation in future studies.

The highest prevalence of diarrhoea among children under five years of age was children aged 2-3 years. Our findings are consistent with studies in Mbour, Senegal [38], and other Low- and Middle-Income settings, where children aged 1 to 3 years exhibited the highest diarrhoea prevalence. This age group is more mobile, engages in exploratory behaviours, and has been therefore more frequently exposed to contaminated environmental surfaces, contributing to an increased risk of infection [23, 38]. The proportion of diarrhoea cases were higher among male children than among female children. This is consistent with some studies and contrasts with other studies with higher number of female children presenting with diarrhoea in Iran, Pakistan and Tanzania [38, 39, 40]. The results of this study indicates that male children are more likely to have diarrhoea than female children. Therefore gender-specific health promotion programs may be warranted to mitigate the higher diarrhoea burden among male children. Other reasons for a higher risk for male children include behavioural and social factors, such as different hygiene practices, or may be due to cultural practices, that favour male children over female children, which may impact on care [25, 38].

The significant increase in diarrhoea prevalence during and after COVID-19 indicates several contributing factors, including pandemic-related healthcare disruptions, limited access to immunization and sanitation in, and potential direct effects of SARS-CoV-2 on gastrointestinal health [25]. However, there is no data on COVID-19 testing in patients that are presented at Masiphumelele clinic. Additionally, the negative impact of COVID-19 pandemic on routine child health services, including diarrhoea treatment and preventative measures, is well documented in South Africa [13, 41, 42]. While hygiene interventions, such as handwashing and wearing masks, may have temporarily alleviated some infectious diseases, the lack of widespread access to handwashing facilities in informal settlements limited compliance with these measures [16,43]. Furthermore, the significant increase in diarrhoea prevalence could be due to the lack of childhood diarrhoea interventions at primary health clinics during the COVID-19 pandemic, such as targeted one-on-one meetings with residents and caregivers, which were not as frequent due to lockdown restrictions and social distancing measures [36].

The results emphasised the necessity of targeted interventions to address diarrhoea in children under five years of age, during the high-risk warm season, particularly in the months of November to February. Age-specific strategies should focus on the most vulnerable groups, such

as children aged 2-3 years, while healthcare workers should be aware of the higher prevalence of diarrhoea among male children and adopt gender-specific approaches to reduce this risk. Future pandemic responses must include measures to maintain and improve public health services, particularly related to the prevention and treatment of diarrhoeal diseases.

Further investigation is warranted to also examine specific risk factors that contribute to the increase in diarrhoea cases, including environmental, socioeconomic, and healthcare-related factors.

Several limitations of this study should be noted. The retrospective study design relied on clinical records, which may not have all cases of diarrhoea, particularly those treated at home, or in other healthcare facilities [43], resulting in underestimation of the prevalence. Additionally, this selection bias may have resulted in an underrepresentation of mild diarrhoea cases while overrepresenting more severe cases requiring clinical care. The lack of microbiological data limited the identification of specific pathogens that contributed to the burden of diarrhoea, limiting inferences about aetiological patterns [38]. Furthermore, because of the anonymous records used, a key limitation of this study is the inability to distinguish first time cases from repeat admissions, which may overestimate the prevalence [8]. Additionally, the length of stay, interventions required, death, and complications were not analysed and socio-demographic variables, such as household income and sanitation practices, were not investigated. This information could provide a more comprehensive understanding of the burden of disease and risk factors. These limitations may affect the generalizability of results to other regions or settings with differing healthcare systems and environmental conditions.

However, the strengths of this study include a large dataset spanning five years allowing for robust analyses of temporal, seasonal, and demographic trends. The focus on a vulnerable population in an informal settlement provides important insights into the epidemiology of diarrhoeal disease in similar resource-constrained settings. Additionally, studying the effects of the COVID-19 pandemic provides timely evidence for informing future public health and pandemic preparedness in informal settlements.

Although this study did not directly assess water, sanitation, and hygiene (WASH) exposures, previous research was referenced to contextualise the findings within known environmental determinants of diarrhoeal disease. The role of WASH in shaping childhood diarrhoea risk remains a critical consideration in informal settlements and should be explored in future studies using dedicated indicators.

Conclusion

This study highlights a concerning increase in diarrhoeal cases among children under five years of age in Masiphumelele from 2019 to 2023, with a significant escalation during the COVID-19 pandemic. The findings reveal clear seasonal patterns, with peaks in diarrhoea cases occurring in the warmer months and indicate that boys and children aged 2-3 years are disproportionately affected. These findings underscore the urgent need for targeted interventions in informal settlements to mitigate the increasing burden of childhood diarrhoea. Public health efforts should prioritize improving access to safe drinking water, enhancing sanitation infrastructure, and implementing seasonal preparedness initiatives, particularly in high-risk months. Additionally, age-specific and gender-sensitive interventions—such as focused hygiene education for caregivers of boys aged 2–3 years—may help reduce diarrhoea transmission.

Furthermore, the study highlights the broader implications of healthcare disruptions during public health emergencies, such as the COVID-19 pandemic, on childhood disease patterns. Strengthening healthcare systems and ensuring continuous access to diarrhoea prevention and treatment services during crises is critical to improving child health outcomes. Future policies should integrate climate-adaptive WASH (Water, Sanitation, and Hygiene) strategies to address seasonal spikes in disease prevalence and ensure resilience to future public health disruptions.

Future research should further investigate the specific environmental and socio-economic risk factors contributing to the rising diarrhoea burden in informal settlements and evaluate the effectiveness of existing interventions. By integrating evidence-based strategies into policy and practice, local governments and health authorities can implement sustainable solutions to reduce childhood diarrhoea and improve health equity in vulnerable communities.

List of abbreviations

CI- 95% Confidence interval

DALYS- Disability-Adjusted life years

HREC- Human Research Ethics Committee

P-value- Probability value

Declarations

Ethics approval and consent to participate

Ethical approval was requested from the University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee (HREC), HREC REF NO: 568/2024 and after approval, institutional ethical approval was sought from the City of Cape Town, City Health Department, REF: 10969 for access of patient records from Masiphumelele Clinic through the Health Information Office.

The data was collected as part of routine care in clinics for diarrhoea; therefore, no individual consent was required or possible. Anonymity and confidentiality were maintained as the participants names were not recorded on the spreadsheet and the Health Information Office only provided de-identified data. The data record sheet was stored on a password protected Microsoft Excel cloud document, which requires multi-factor authentication, and which only the researcher and supervisor were granted access to.

Consent for publication

Not applicable

Availability of data and materials

The data that support the findings of this study are available from City of Cape Town, Health

Information Office but restrictions apply to the availability of these data, which were used under request for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission from City of Cape Town.

Competing interests

The authors declare that they have no competing interests.

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Authors contribution

MJ and PM conceptualized and designed the study. PM acquired the data. PM and MJ analysed and interpreted the data. PM drafted the article and MJ revised it. Both authors read and approved the final manuscript.

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Part B: Appendices

Part B consists of the following appendices:

Appendix A: Research Protocol

Appendix B: Ethics approval letter from the University of Cape Town

Appendix C: Ethics approval from the City of Cape Town

Appendix D: Instructions for Authors for the Target Journal- BMC Public Health

Appendix A: Research Protocol

Topic: Prevalence and Trends of Diarrhoea in Children Under Five at Masiphumelele Clinic, Cape Town, South Africa (2019-2023)

1. Introduction

1.1 Background

Diarrhoea is the second leading cause of death in among children under five years old with statistics sitting at 443 832 childhood deaths per year globally (WHO 2017). In sub-Saharan Africa, children under the age of five experience episodes of diarrhoeal diseases three times a year on average (Boschi-Pinto et al. 2006). In South Africa, diarrhoeal disease is the second cause of death for under-fives and counted 8.8% of the total years of health life lost (DALY (disability adjusted life years)) (Nguyen et al. 2021).

Clean water, basic toilets and good hygiene practices are essential for survival, good health, and wellbeing. However globally, close to 780 million people are without quality drinking water, while 2.5 million people are without proper sanitation (WHO 2017). Due to the legacy of Apartheid, people in rural areas and people living informal settlements lack basic municipal services such as adequate water supply, waste management, sanitation, and health care. To access health care, they must travel elsewhere.

Although Primary Health Care is free it comes at the cost for the less privileged because they must travel long distances. The South African government has made strides in reducing the percentage (%) of households without sanitation from 12.6% to 3.1% (Stats SA 2022). There is still a lack of proper sanitation facilities in informal settlements due to the rise of urbanization and the urban population migrating from rural areas. Furthermore, communal toilets and taps are used in informal settlements and households share toilets and taps (Brown et al. 2013). This compromises the hygiene of the toilets and taps due to different behaviours

around the use of these facilities. Most of these toilets and tapes are not compatible for children, making it difficult for them to use (CENSUS_CT 2011; Cityfacts 2015).

The lack of access to running water in the household leads to people having to containerise water for use at the later stage for drinking or food preparation, which can result in contamination and be followed by a possible risk of infectious diseases. Furthermore, informal settlements can be exposed to contaminated water because they live around canals where night soil is thrown because of not having access to adequate sanitation (Govender et al. 2011; Madliwa 2011).

Lack of service delivery is also a leading role in causing poor water, sanitation and hygiene as informal settlements are too congested, making it difficult to install and maintain some of the services within informal settlements (Govender 2011). The informal structures built in the informal settlement are exceedingly small resulting in overcrowding. Overcrowding raises demand for water and sanitation and practicing hygiene in an overcrowded environment is difficult, and it raises chances of contamination (Madliwa 2011; Maina 2017).

Another factor is the increasingly difficult nature of managing solid waste (Daso and Osibanjo 2012; Nathi and Sharm 2017). This is due to the increasing populations that results in more generation of solid waste. Due to the high population density in the informal settlements, water and sanitation is overburdened resulting in malfunctioning and shortage of such services. This compels the use of other unsafe means like using unsafe water, storing of water for a longer period, and use of buckets for sanitation means. At some instances, the same buckets are used for both storage of water and sanitation. All these factors contribute to diarrhoea infections and its spread, especially to children.

1.2 Problem Statement

Diseases like cholera, diarrhoea and other related diseases remain the most devastating infectious disease in many informal settlements due to poor water, sanitation, and hygiene (Van der Westhuizen et al. 2019). The vehicles causing the diseases prefer places that lack proper waste disposal, poor housing structure and overcrowding. In South Africa, there are about 1.1-1.4 million households in the informal settlements, 2.9-3.6 million people are living in about 4297 informal settlements (Govender et al. 2011; Weimann and Oni 2019). In Cape Town, about 146000 households are in the city's 464 informal settlements (CENSUS_CT 2011; Musengimana et al. 2016).

Adequate water and sanitation play a significant role in preventing many infectious diseases, particularly waterborne diseases, as the hygiene standard is met. Studies that investigated the health and urbanisation in South Africa have stressed the importance of water and sanitation in addressing the spread of infectious diseases and for improving living conditions (Weimann and Oni 2019).

Due to lack of maintenance and overburden of sanitation system, the drainage blocks frequently and causes sewer water to flow on the roads and into storm-water channels. This contaminates water sources like rivers, which people use because of lack of adequate water supply. Moreover, children play on the streets and enjoy playing with water, which leads them to play around the sewer water. This is one of the pathways of diarrhoea spread (Govender et al. 2011).

In the sub-Saharan African countries, South Africa is one of the leading countries in urbanisation, with 66% of population living in the urban areas and the numbers continue to increase up to date. This gives a burden in the provision of resources and services (Nguyen et al. 2021). South Africa is fast growing when it comes to informal settlements. Informal

settlements are characterised by poor housing conditions and inadequate services and are associated with an increased risk of disease and ill health (Van der Westhuizen et al. 2029; Weimann and Oni 2019). Most of the informal settlements in South Africa lack access to adequate basic services like water, sanitation, healthcare, housing, and waste services. The housing structure is built with corrugated iron with inadequate ventilation. These structures are exposed to natural disasters due to the location where they are built. Some structures are built in wetlands, making it difficult to provide basic services (Govender et al. 2011).

Informal settlements pose health risks particularly to vulnerable populations, such as children, the elderly, and people with suppressed immune systems, and are likely to aggravate gender-related inequalities (Govender et al. 2011; Reyes et al. 2012). Infectious diseases like TB, Cholera and diarrhoea are associated with informal settlements as well as other conditions like mental disorders, which includes stress and depression (Thelwell 2020; Groenewald et al 2015). Therefore, there is a need to identify the prevalence and trends of diarrheal cases for vulnerable populations, such as children, in informal settlements, such as Masiphumelele to provide recommendations that can address the burden of diarrhoea in informal settlements in South Africa.

1.3 Literature review

The focus of the literature review is on the water, sanitation, and hygiene (WASH) factors that contribute to diarrhoea in informal settlements:

1.3.1 Diarrhoea- Definition and Etiology

Diarrhoea is defined as the passage of three or more loose or liquid stools per day, or more frequently than is normal for the individual (WHO 2017; Cleveland Clinic 2020). Diarrhoea is spread through ingesting food or drinking water that is contaminated with faecal matter or from person to person resulting from poor hygiene (Jullian 2016; Khalil et al. 2018).

Diarrhoea is classified clinically into 3 classes, namely;

- Acute watery diarrhea. It lasts for several hours or days and it includes cholera
- Acute bloody diarrhea, which is also called dysentery
- Persistent diarrhea, which lasts for 14 days (about 2 weeks) or longer. (Cross and Coombes 2014)

Diarrhoea involves a number of symptoms of infections that are caused by bacteria, virus and parasite organisms (Medicalnewstoday 2014). Most of them are commonly spread by faecal contaminated water which is common in areas with inadequate water, sanitation, and hygiene. Escherichia coli and Vibrio cholera were found to be responsible for 49% of diarrhoeal infections in hospitalised patients from middle income and poor countries (Fischer et al. 2010). In low-income countries, rotavirus and Escherichia coli are the most common etiological agents of moderate to severe diarrhoea in children under 5 years (Fischer et al. 2010).

Viruses are one of the vehicles/vectors that cause diarrhoea. They are known to cause acute infectious diarrhoea, and this include viruses such as norovirus, rotavirus, etc. It is reported that notavirus is associated with one-fifth of all infectious diarrhoea cases and it mostly affects both children and adults, causing over 200 000 deaths annually in developing countries (Nemeth and Pfleghaar 2022). Rotavirus is known to be a common cause of severe diarrheal diseases in children under 5 years, responsible for 35% deaths globally for children under 5 years (GBD_2027 2020).

Bacteria also cause acute infectious diarrhoea. These bacteria include Shigella, Bacillus cereus, Staphylococcus aureus, Salmonella, Campylobacter Vibrio spp., and enterotoxigenic Escherichia coli (ETEC). These bacteria are known for causing acute diarrheal disease. Children under 5 years and adults are affected by these bacteria. Salmonella is mostly found

in poultry, eggs, and milk. Shigella causes Shigellosis which is present bloody mucosal diarrhoea. Clostridiodes difficile infection is usually responsible for watery diarrhoea (Akhondi and Simonsen 2023; Health Direct 2024). Reheating fried rice can cause food poisoning if Bacillus cereus infection is present in the food and seafood like shellfish are susceptible to Vibrio cholera contamination (Akhondi and Simonsen 2023).

Protozoan Cryptosporidium is considered the leading cause of morbidity and mortality in children under 5 years. It was first recognised as a vehicle causing diarrhoea in 1976. This parasite causes an infection in the small intestine thereby causing damage to the absorption and barrier function. It affects childhood growth and wellbeing (Khalil et al. 2018). Entamoeba is another parasite resistant to chlorination, thus found in high contaminated water. Children under 5 years are the most affected (Khalil et al. 2018).

Diarrhoea is mostly associated with environmental and socio-economic conditions and people who live in impoverished communities are the most vulnerable and affected by diarrhoea. These are people who live in informal settlements as the areas do not have safe water sources and adequate sanitation. Some of them cannot seek medical assistance timeously due to their socio-economic conditions (Nguyen et al. 2021). These conditions aid the transmission and spread of diarrhoea.

1.3.2 Transmission and the spread of Diarrhoea

Diarrhoea can be transmitted directly or indirectly through faeco-oral routes (ingestion) (Julian 2016). Diarrheal pathogens can be found in water and food and can also be caused by poor personal hygiene. When food is prepared or stored in unhygienic condition, improper storage with no temperature control, it can lead to food poisoning, resulting in diarrheal disease (Julian 2016; Medicalnewstoday 2024; Health Direct 2024).

Unsafe storage and poor handling of domestic water can also contaminate the water, mostly with Escherichia coli, and result in diarrheal infection. This type of parasite is highly resistant to disinfectants such as chlorine. These routes of entry make it possible for the parasite to be endemic in low-income countries and epidemic in high income countries (Khalil et al. 2018).

1.3.3 Diarrhoea morbidity and mortality

Diarrhoea is one disease that causes morbidity and mortality around the world, especially in children under the age of 5 years. Diarrhoeal diseases are considered to be the second leading infectious cause of mortality globally in children under 5 years. In 2017, an estimation of 533 768 deaths among children under 5 years was experienced globally. This is the mortality rate of 78.4 deaths per 100 000 children (GBD_2027 2020). There is evidence to suggest diarrhoea can impair childhood growth and increase the risk of subsequent infectious disease (GBD_2027 2020). In 2016, Cryptosporidium infection was responsible for 48 301 deaths in children under 5years and 4.2 million acute disability adjusted life-years lost globally. The protozoa Cryptosporidium parasite affects childhood health beyond acute illness through compromising the growth in terms of weight and further increases the risk of infectious disease episodes (Khalil et al. 2018; GBD_2027 2020).

In 2016, sub-Saharan Africa was the leading region with Cryptosporidium associated deaths and DALYs (disability adjusted life years) in children under 5 years old across the globe. In the Western sub-Saharan Africa, a total of 28 396 death and total DALYs of 6.1 million, followed by Central sub-Saharan Africa with 7387 deaths and total DALYs of 2 million; Eastern sub-Saharan Africa recorded 6237 deaths and 2.1 million total DALYs. Lastly, in Southern sub-Saharan Africa, 719 deaths and total DALYs of 208 445 were recorded. Western and Central sub-Saharan Africa were the highest in the region (Khalil et al. 2018).

In 2017, sub-Saharan Africa was considered the region with the highest diarrhoea mortality rate. Western sub-Saharan Africa recorded a mortality rate of 269 deaths per 100 000 children, and central sub-Saharan Africa recorded a mortality rate of 176 deaths per 100 000 children (GBD_2027 2020).

In 2000, diarrheal disease was the third cause of death in all ages, especially children under 5 years in South Africa. The death rate because of diarrheal disease was sitting at 19% in children below 5 years. Studies of non-communicable diseases reveal that diarrhoea counted 8.8% of the total years of health life lost (DALY). In 2010, diarrheal disease become second cause of death in South Africa (WHO 2017, Nguyen et al. 2021). Statistics South Africa (Stats SA 2022) estimates that 20% of under-five deaths may be attributed to diarrhoea, with 31,436 diarrhoea cases recorded in 2016, while other sources estimate the mortality rate between 8%–24% (Nguyen et al. 2021, AMREF 2007). Diarrhoeal disease varies according to seasons and the age of a child and in South Africa, the high number of cases in the summer months (December to February) are due to bacterial pathogens and the high number of cases in the winter months (June to August) are due to rotavirus (Awotiwon et al 2016)

1.3.4 Prevention control and treatment of diarrhoea

The WHO recommends the use of expanded rotavirus vaccination to prevent severe diarrhoeal infection. The use of this vaccination has contributed to the reduction of 2,1% mortality in children under 5 years and has prevented close to 30 000 deaths in 2016 among children under 5 years (Nemeth and Pfleghaar 2022; Carvajal-Velez et al. 2016). Universal access to oral rehydration solution and antibiotics use has proven to reduce global mortality rate in children under 5 years in the year 2000-2016 (GBD_2016 2018; Garza and Cohen 2011). Vitamin A supplementation and zinc supplementation have also been effective in diarrhoea prevention and treatment (Nemeth and Pfleghaar 2022).

The WHO guidelines recommended that suspected episodes of Shigella-associated diarrhoea be treated with the appropriate antibiotics (GBD_2017 2020; Shrestha et al. 2023). As per the sixth goal of the Sustainable Development Goals, the WHO promotes the adequate provision and improvement of water, sanitation, and hygiene to all people as one of the most effective ways to prevent diarrhoea (WHO 2017, Omelonye et al. 2015).

There are several preventive interventions for diarrhoea in South Africa that are implemented. The interventions include rotavirus vaccine, vitamin A supplementation, and the water, sanitation, and hygiene (WASH) programmes that include water connections in homes or improved water source, improved sanitation, hand washing with soap and hygienic disposal of children's stools. However, WASH remains a challenge in South Africa as there is no adequate provision in poor communities (Chola et al. 2015).

Oral Rehydration Solution (ORP) and antibiotics are also utilised for the treatment of diarrhoea. In every clinic in Cape Town, there is ORT corner to emphasis the use of this mechanism (Chola et al. 2015). Breastfeeding promotion and addressing severe wasting and moderate acute malnutrition is also implemented as they have an indirect impact on diarrhoeal mortality (Chola et al. 2015).

Health education and health promotion are important and effective interventions to raise awareness on preventing and treating diarrhoea. Nurses, community care workers and Environmental Health Practitioners (EHPs) conduct projects and campaigns in communities to give awareness to prevent diarrheal prevalence. EHPs and nurses conduct home visits for investigations when there is a diarrheal case to prevent an outbreak or when there is an outbreak.

1.3.5 Water, sanitation, and hygiene (WASH)

Definitions

(a) Safe Drinking Water is defined as water that does not represent any significant risk to health over the lifetime of consumption, including different sensitivities that may occur between life stages (WHO Guidelines 2022).

(b) Sanitation refers to conditions relating to public health, especially the provision of clean drinking water and adequate sewage disposal (Hutton and Chase 2017).

(c) Hygiene refers to conditions and practices that help to maintain health and prevent the spread of diseases (WHO Africa 2023).

The Sustainable Development Goals, also known as the Global Goals, were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity (South Africa 2005). Goal 6 declares the importance of achieving clean water and sanitation for all (South Africa 2005). To describe water as the engine of life will not constitute an overstatement. This is because water in its various forms, accounts for more than 70 percent of the entire earth surface (Daso and Osibanjo 2012).

Sanitation describes the disposal of human faeces and urine, wastewater and rubbish in order to maintain hygienic conditions (Mitchell 2015). Hygiene is a series of repetitive behavioural practices that are performed to maintain health and to prevent infectious diseases. To achieve hygiene, basic services like safe running/drinking water, adequate sanitation, adequate housing, waste removal and access to healthcare must be provided (Omelonye et al 2025).

Forty percent of the world's population lacks access to adequate supplies of water and sanitation services to sustain human health (Bouabid and Louis 2005). Providing safe water and sanitation to the community is a basic precondition for improving health and alleviating poverty. An adequate supply of safe drinking water is essential for a healthy life, but waterborne disease is still a major cause of death in various parts of the world.

1.3.6 WASH Risk Factors for Diarrhoea in informal settlements

The lack of service delivery in informal settlements plays a leading role in causing poor water and sanitation as it is difficult to install water supply lines due to congestion and structures being built in wetlands (Llling 2008; Living Hope 2000). Another factor is the increasingly difficult nature of managing solid waste (Cityfacts 2015; Maina 2017). This is due to an increase in population which results in more generation of solid waste.

As one of the causes of poor water and sanitation, studies and survey conducted in the informal settlement reveal that (Deilami et al. 2017);

- Plumbing material being used is of inadequate quality
- Broken cisterns are not replaced and attended to by plumbers
- The water meters are always faulty
- Plumbers do not fix water leaks
- The water flow pressure from the taps is low

Children are not catered for when it comes to sanitation. This results in children having to use open fields, sharing buckets/ potties to relieve themselves. If there are canals in informal settlements, they are often not secured therefore people use the canals to dispose of night soil thus contaminating the water. Additionally, children may also play in these canals which have contaminated water. This can cause diarrhoea resulting in loss of valuable nutrients in the

body and disturbance in absorption from the gut in children under five years. This impacts children negatively as their bodies are still developing (Nath and Sharma 2017; Shrestha et al 2023).

1.3.7 Improving water, sanitation, and hygiene in informal settlements

The sixth goal of Sustainable Development Goals (SDG–6) is imperative to improve sanitation practices and access to clean water supplies in a safe and sustainable manner (Bouabid and Louis 2005; Han et al. 2016). Identification of areas vulnerable to waterborne diseases is essential for protecting community health. This is particularly important in developing countries where unsafe disposal of domestic wastewater and limited potable water supply pose potential public health risks (Madliwa 2011; Shrestha et al 2023].

These include both interventions that directly provide ‘hardware’ for excreta disposal, through new or improved latrines or connection of existing latrines to the public sewer, and that provide the ‘software’ for hygienic practices, including hygiene, health education and the encouragement of specific behaviours such as hand washing with soap (Cross and Coombes 2014).

Teaching people the causes of gastrointestinal illness and how to prevent it makes a significant difference to the likelihood that such diseases will be common in their households. Families where the mother has a low level of education have consistently been found to have higher prevalence of diarrhoea and of intestinal parasites (Mitchell 2015). Increase in service delivery (collecting of solid waste frequently, monitoring and maintenance of the facilities) can also play a major role in improving water and sanitation quality (Llling 2008).

The use of Oral Rehydration solution remains the most effective means of treating diarrhoea. However, clinics make provision of oral rehydration corner only during diarrheal season. Promotion of the oral rehydration solution and education is also done during the season

through projects and campaigns. These interventions must be a day-to-day programme, as diarrhoea does not wait for a season (Bos et al. 2016).

Personal hygiene and hand washing with soap and safe water has been one of the most effective ways to prevent many infectious diseases. Washing of hands with fresh water and soap before preparation of food, after using toilets or taking any part of the body can prevent diarrhoea. Washing food, especially ready to eat products like vegetables and fruits is important. Keeping water closed properly when kept in containers can prevent contamination. People without taps in their households must use best available and practicable methods like a squeeze bottle or tappie-tap to wash hands (Maina 2017).

Regulatory boards should involve communities at a group level. Here the community groups align at the interaction level, where they can be used to effect regulations and perform context- specific evaluations. The importance of custodianship in the appropriation of space cannot be stressed enough. Without the uptake of community members, initiatives meant for socioeconomic development cannot thrive. In this light, connections between built facilities and the communities they serve play a vital role in drawing together the distinct measures of equitable access to water and sanitation (Maina 2017).

1.3.8 Government policies for water and sanitation in South Africa

Water management in South Africa is divided into three spheres of government: national government, provincial government, and local government (Adom and Simatele 2021). National and local government work hand in hand with each other as they play a significant role in the provision of water and its management. Provincial government deals with the coordination of the Integrated Development Plan and Water Services Development Plan (Adom and Simatele 2021). The Constitution of South Africa, Act no 108 of 1996, allocates

responsibilities to the spheres of government of which the provision and management of water has been allocated to local government (Adom and Simatele 2021).

The Water Services Act (WSA) 108 of 1997 deals with water services institutions responsible for providing accessible and adequate water supply and sanitation.
Municipalities are mainly the ones enforcing this policy in order to comply with the Bill of Rights (Adom and Simatele 2021). The National Water (NWA) Act 36 of 1998 deals with the efficiency, equity, and stability of all water services. The National Water Resource Strategy (NWRS) 2024 provides the framework for the development, conservation, management, and control of water resources. The NWRS is used to implement the NWA policy and create a space for collaboration amongst all departments across the three spheres of government. (Adom and Simatele 2021)

1.3.9 Gaps in policies

These policies focus on provision of water as a need. However, it does not stress that the purpose is to prevent infectious diseases, particularly waterborne diseases. It does not seem that health professionals were involved in the drafting of the policies. These policies are good on paper and well-articulated; however, little has been achieved in implementation and monitoring despite the policies being good. NWA did not do much in closing the gap for the people who did not have access to water services. NWRS has failed to provide the required needs for people. The National water policies fail to provide clarification on the principles that need to be utilised to meet basic water needs for people, in particular the disadvantaged. These policies are more focused on agricultural sectors as compared to ordinary South Africans. Research revealed that 95% of water resources is used for commercial farming

(Madliwa 2011; Adom and Simatele 2021).

The implementation of these policies is poor in all the spheres of government. The national implementation strategy is not in line with local activities due to lack of public participation. Another reason is that the stakeholders involved in the policy drafting are international donors who do not have background and knowledge of our local context (Govender et al. 2011; Madliwa 2011; Adom and Simatele 2021)

Infrastructure is also another major challenge that caused failure in the implementation. The policies are focused on well-established infrastructure, which made it difficult to be implemented in areas without adequate infrastructure. Most rural areas do not have adequate infrastructure and where they have, such infrastructures are not maintained and are poorly managed. This makes it impossible for rural areas to benefit from these policies (Bouabid 2005).

These polices do not address the issues of informal settlement. Informal settlement needs a different approach due to the type of building structure they have and the type of land they have occupied. These policies do not address how they will ensure that people in those areas have water services and sanitation. There is no policy specifically for informal settlements. A water and sanitation policy focusing on the context of informal settlements to provide services relevant to such areas.

1.3.10 Gaps in the literature

Sustainable Development Goal number 6 (SDG–6) is committing to improve sanitation and access to safe water that is sustainable (Han et al. 2016). Not much progress has been made on SDG-6. Water and sanitation have been provided to people; however, the suitability of such services remains a major problem. Many of these services do not cater to children. Many designers, manufacturers and project managers do not have children in mind when they coordinate such projects as children are expected to use infrastructures that are meant for

adults (Nguyen et al. 2021). In most informal settlements, toilets and taps are communal, thus, children are expected to compete with adults for the use of such services. With eight years left before the intended achievement of the SDGs by 2030, it remains uncertain if there will be such an achievement. These policies do not address the issue of water and sanitation according to the needs of children. They do not address the infrastructures that will be user-friendly for children. The rights of children regarding water and sanitation are not addressed.

There is a lack of literature that addresses the health conditions of residents living in informal settlements. The latest literature that reported on diarrhoea globally was in 2016 (Cros and Coombes 2014; Han et al. 2016). Very few literatures focus on diarrhoea for children under the age of 5 years. The recent study on diarrhoea in Cape Town, Western Cape, was from 2021, however, the data that was used was collected in 2017 (Nguyen et al. 2021).

No study has been conducted in the study area (Masiphumelele) to examine the prevalence of diarrhoea; therefore, this gap makes it rational to conduct a new study. The findings from this study will provide baseline data and information, especially for future interventions to reduce diarrheal diseases and improve water and sanitation facilities in Masiphumelele.

Water and sanitation are recognized as one of the most predominate basic needs. Provision of available, accountable, accessible, and suitable water and sanitation is important and a key to prevention of infectious diseases associated with it.

The increases in waterborne diseases in informal settlements are due to poor housing, overcrowding and poor water, sanitation, and hygiene conditions (Weimann and Oni 2019). This study is important to try to prevent or reduce waterborne diseases in the informal settlement of Masiphumelele, Cape Town, South Africa. It is noted that sources and burden of early childhood diarrhoea are multidirectional and that makes it difficult to establish the actual cause. Moreover, there is less information regarding the situation in informal

settlements. This gap motivates more studies to be conducted to break down the underlying causes and to understand the trends (Nguyen et al. 2021).

The study will help formulate suitable strategies to smoothen operations of water and sanitation supply and to improve service delivery. Prevention or reduction of infectious diseases is also a motivational factor to run the study. Effective intervention will be identified or formulated during and at the end of the study.

1.4 Aim, research questions, and objectives

1.4.1 Aim

The aim of this study is to determine the prevalence of diarrhoea in children under five years of age amongst all admissions in Masiphumelele clinic, Cape Town, South Africa over a five-year period (2019-2023)

1.4.2 Research questions

1. What is the trend in the prevalence of diarrhoea in children under five in Masiphumelele over a 5-year period from 2019-2023?

2. What are the demographic characteristics of children under the age of five presenting with diarrhoea at Masiphumelele clinic?

3. What are the monthly variations in diarrhoea cases amongst children under five years in Masiphumelele?

4. What are the measures related to water and sanitation that can be recommended to reduce the burden of diarrhoea in Masiphumelele?

1.4.3 Objectives

The objectives to address the study aim are:

- To quantify the prevalence of diarrhea in children under five years of age reported in Masiphumelele clinic from 2019 to 2023
- To analyze the demographic characteristics (age, gender) of children under five reported as diarrheal cases in Masiphumelele clinic
- To identify the monthly variations in diarrheal cases of children under five reported in Masiphumelele clinic
- To understand the burden of diarrhoea for children under five years in Masiphumelele for the period 2019 to 2023 to provide environmental health recommendations targeted for informal settlements

2. Methodology

2.1 Study design

A quantitative descriptive cross-sectional study design will be conducted analysing secondary data between the years 2019 to 2023. The study will focus on the prevalence of diarrhoea in children under five years of age reported to Masiphumelele clinic, using data obtained from City of Cape Town Municipality City Health Department. A descriptive crosssectional study quantifies the extent of a health problem or burden of disease in a population which in this case is the prevalence of diarrhea in children under five years of age in Masiphumelele between 2019 and 2023.

2.2 Study area, population, and sampling

2.2.1 Description of study area

Masiphumelele is a formal and informal settlement in Cape Town, South Africa, situated between Kommetjie, Capri Village and Noordhoek, initially known as Site 5 (Figure 1). The area was renamed “Masiphumelele” by its residents, which is a Xhosa word meaning “let us succeed”. The area has a formal side and an informal side which is divided into sections (Section A-E, Section Z, School Site, Kolobe and Amakhayangoku). About 400-500 people first settled in the area in the 1980s and has grown to a population of 15969 with 5088 households (SAHO 2019, Hokisa 2002). According to 2011 South African Census (Statistics South Africa), the population was at about 21 904, with household of 7413 and the average household size was 2.95 (CENSUS_CT 2023; Stats SA 2022).

The area has 53% males and 47% females. Population size in terms of age group; 0-4 years (which is the focal group for the study) is 961 (12, 28%), 5-19 is 6530 (20.42%), 20-59 I 19961

(62, 43%) and 60-85+ is 2089 (6, 52%). Infectious diseases are prevalent in Masiphumelele with approximately 23-28% of the population is HIV positive, and many of these are affected with TB (Desmond Tutu Health Foundation, 2023). As a result, there are many orphaned children and many who support families on their own. The unemployment rate is estimated at 30.96% (Cityfacts 2015; Living Hope 2000).

Figure 1: Map of Masiphumelele

2.2.2 Study population and sampling

Masiphumelele Clinic is a primary healthcare clinic operating in the South Peninsula Health District of the Metro Region serving the area. The data from the clinic will be reviewed for all child patients treated for diarrhea between January 2019 and December 2024. The eligible group for this study is children between 0 to 5 years old

Inclusion criteria

All children between 0-5 years of age who attended Masiphumelele clinic over the time period of 1 January 2019-31 December 2023 were diagnosed with diarrhoea.

2.3 Data collection

The data source utilized will be secondary data collected from Masiphumelele Clinic City of Cape Town. Ethical approval will be requested from the Faculty of Health Sciences Human Research Ethics Committee (HREC) and once approved, institutional ethical approval will be sought from the City of Cape Town Health Department for access of patient records from

Masiphumelele clinic. All medical records from 1 January 2019 to 31 December 2023 will be requested in order to calculate the prevalence of diarrhoea in children under five years old. All patient data will be requested so as to calculate the prevalence of diarrhoea of children under five years old will be calculated from the clinic's patient population from 2019 to 2023.

2.4 Data Analysis

Descriptive analysis will be performed with R Statistical Software. The data will be checked to ensure there is no missing data before proceeding with analysis. If there is missing data for age in the spreadsheet, only then will the physical records be accessed to fill in the missing information. If the information does not exist, then the particular patient will be excluded, and this study will report the number of entries excluded due to missing data.

To meet objective one, which is quantify the prevalence of diarrhea in children under five years of age reported in Masiphumelele clinic from 2019 to 2023, the prevalence of diarrhoea of children under five years old will be calculated from the clinic's total patient population from 2019 to 2023. The total number of patients reporting to the clinic, the total number of diarrhoea cases (all ages) and the total number of diarrhoeal cases for children under 5 years of age will be reported over the five-year time period. The annual trend childhood diarrhea admissions for the five-year time period will also be reported to identify annual increases or decreases as well as calculating if the differences in diarrhoeal cases over the five years are statistically significant.

The COVID-19 pandemic falls within the study period, specifically the South African national lockdown period with various levels of societal restrictions, from 22 March 2020 to 22 June 2022 (Hussey et al 2024). Acute diarrhoea, and other gastrointestinal symptoms, are common in COVID-19 infections, affecting approximately 10-20% of COVID-19 patients

and in some cases, can be presenting as the only COVID-19 symptom (Friedel and Cappell 2023). Therefore, the COVID-19 pandemic could have an impact on diarrhoea cases.

It is noted that neonates and young children infected with COVID-19 have milder clinical presentation, especially children under 5 years (Pillai et al 2023), which is the population of interest in this study. Additionally, populations living in informal settlements in Cape Town were found to have higher seroprevalence of SARS-Cov-2 which inferred protection against severe COVID-19 infection (Hussey et al 2024). Although not an explicit objective in this study, the impact of COVID-19 on diarrhoeal cases presented at Masiphumelele clinic will be investigated by comparing the prevalence of diarrhoea for three periods (i) pre-COVID-19 (01 January 2019-21 March 2020), (ii) during COVID-19 (22 March 2020- 22 June 2022), and (iii) post-COVID-19 (23 June 2022-31 December 2023). This will also assist in elucidating the possible reasons if a change in diarrhoeal case trends is significant.

To meet objective two, which is to analyse the demographic characteristics (age, sex) of children under five reported as diarrheal cases in Masiphumelele clinic, the data will be categorized according to age (0 to ≤ 12 months, > 12 months to ≤ 2 years, >2 years to ≤ 3 years, > 3 years to ≤ 4 years, > 4 years to ≤ 5 years) and sex (male, female) (Table 1). The statistical significance of differences in diarrhoeal infections among different ages and sex will be calculated.

To meet objective three, which is to identify the monthly variations in diarrheal cases of children under five reported in Masiphumelele clinic, the data will be categorized monthly to identify monthly and seasonal (summer and winter) variations of diarrhoea in children under five years. The statistical significance of monthly variation will be calculated.

To meet objective four, which is to understand the burden of diarrhoea for children under five years in Masiphumelele for the period 2019 to 2023 to provide environmental health recommendations targeted for informal settlements, the results from this study will be compared to other studies of diarrhoea in children under five years of age in South Africa, and the results of this study will inform recommendations to be made to the City of Cape Town's health department to address childhood diarrhoea in Masiphumelele.

Table 1 depicts how data will be categorized into different variables for analysis

Variable name	Variable	Type of variable
Year 1- 5	January 2019- December 2023	Categorical
Admission month 1-12	January to December	Categorical
Season 1-4	Summer Autumn Winter Spring	Categorical
Age		Numerical
Age group	0 to ≤ 12 months > 12 months to ≤ 2 years, >2 years to ≤ 3 years, > 3 years to ≤ 4 years, > 4 years to ≤ 5 years	Categorical
Sex	Male Female	Categorical

2.5 Logistics and Time schedule

	March 24	April 24	May 24	Jun e 24	July 24	August 24	September 24	November 24	December 24
Ethical approval				√	√				
Data collection						√			

Data Analysis							√		
Write-up								√	
Submission									√

3. Limitations of study

The type of study design (cross-section study) is limited by the inability to assess incidence and because the exposure and outcome are simultaneously assessed. Collection of data might have limitation in that receiving reliable data will be dependent on the secondary data that was collected in the Masiphumelele Clinic, which is a primary health care facility. All primary health care facilities in the City of Cape Town store routine patient information and encounters electronically on the Patient Record and Health Information System (PREHMIS). Each time a patient visits a primary health facility in the City of Cape Town, a series of barcodes are scanned to record diagnosis and services delivered on that visit (Lurie et al 2014).

However, as PREHMIS is a management information system not all clinical information is stored in the system (Lurie et al 2014) and this can hinder analysis as variables of interest may be missing. An advantage of extracting data from the PREHMIS database is that the data is entered according to sequenced actions in standardized data fields (Caldwell, 2023). However, this limits the control of the researcher in analysing other variables of interest as the data are pre-selected. Data entered in PREHMIS is verified monthly however the data is still subject to the data capturing quality at the facility level
(Caldwell, 2023)

Furthermore, by focusing only on patients that present at the facility may result in an undercount of diarrhoea as many patients self-medicate and not all diarrhoeal cases are seen at the clinic (Ramlal et al 2022). Additionally, if people visit other clinics, then the data for

that clinic on repeat cases of diarrhoea are incomplete or if people visited clinics managed by the Provincial Department of Health would not be counted in analysis (Lurie et al 2014). Furthermore, the population is narrow as it is focused on children under 5 years of age only.

4. Ethical Considerations

Ethical approval will be requested from the Faculty of Health Sciences Human Research Ethics Committee (HREC) and once approved, institutional ethical approval will be sought from the City of Cape Town Health Department for access of patient records from Masiphumelele clinic.

4.1 Anonymity and confidentiality

Anonymity and confidentiality will be maintained as the participants' names will not be recorded on the data recording sheet. The data will be stored on a password protected Microsoft Excel cloud document, which can only be accessed with UCT login, which requires multi-factor authentication, and which only the researcher and supervisor will be granted access.

5. Conclusion

Water and sanitation services should be economically, environmentally, and socially sustainable so that future generations can enjoy their human rights to safe drinking water and sanitation. When the study has established the extent to which water, sanitation and hygiene contribute to childhood diarrhea, it will assist in suggesting mitigation strategies that will be implemented in Masiphumelele area. These strategies will be aimed at eliminating or reducing diarrheal disease cases. The gaps identified in this study will assist to influence policy, ensuring that policy makers recognise children’s rights, and that water and sanitation infrastructures are designed in such a way to be user-friendly for children. The

implementation of all these mechanisms has the potential of reducing and preventing diarrheal diseases across the country and in particular Masiphumelele.

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Appendix B: Ethical approval letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room 46, E-53 Old Main Building
Groote Schuur Hospital
Observatory 7925
Email: hrec-submissions@uct.ac.za
Website: www.health.uct.ac.za/home/human-research-ethics

13 September 2024

HREC REF: 568/2024

Dr Meryl Jagarnath
Division of Environmental Health
Email: meryl.jagarnath@uct.ac.za
Student Email: mknpri016@myuct.ac.za

Dear Dr Jagarnath

PROJECT TITLE: INVESTIGATING THE OCCURRENCE OF DIARRHOEA IN CHILDREN UNDER FIVE YEARS IN MASIPHUMELELE TOWNSHIP, CAPE TOWN, SOUTH AFRICA. (MASTER DEGREE - MR PRINCE MOKOENA)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review and approval.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is only granted for one year until the 30 December 2024.

Please submit a progress report, using the standardised Annual Progress Report Forms (FHS016) **or** (FHS 017) if the study continues beyond the approval period. Please submit a Standard Closure form (FHS 010) when the study has been completed, this includes after publication or thesis submission and final completion.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the Master Degree student: Mr Prince Mokoena will also be involved in this study.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC Reference number 568/2024 in all your correspondence.

Yours sincerely

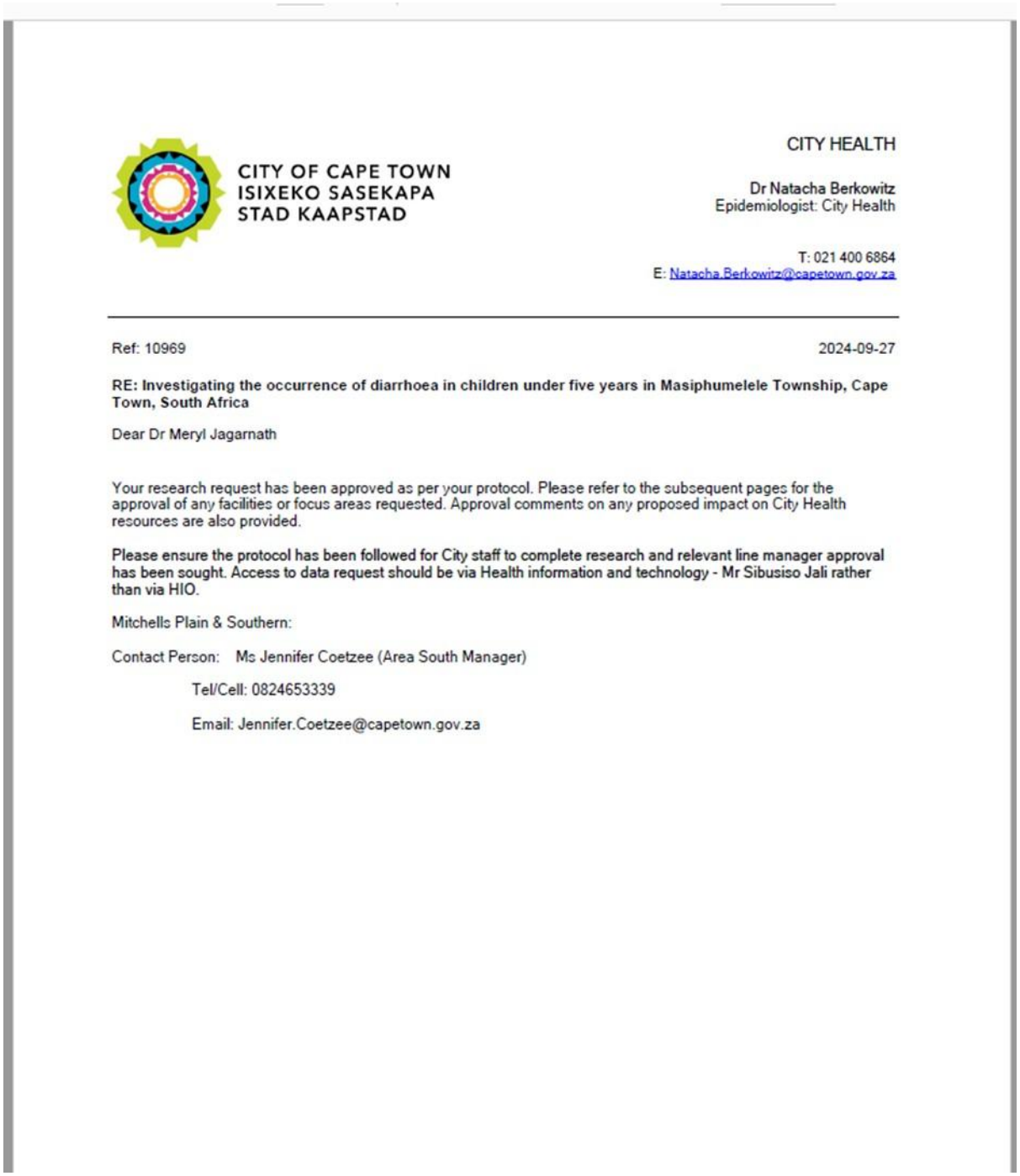
pp TBurgess

PROFESSOR MARC BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637. Institutional Review Board (IRB) number: IRB00001938 NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2020), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC REF NO. 568/2024

Appendix C: City of Cape Town Research approval letter



CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

CITY HEALTH

Dr Natacha Berkowitz
Epidemiologist: City Health

T: 021 400 6864
E: Natacha.Berkowitz@capetown.gov.za

Ref: 10969

2024-09-27

RE: Investigating the occurrence of diarrhoea in children under five years in Masiphumelele Township, Cape Town, South Africa

Dear Dr Meryl Jagarnath

Your research request has been approved as per your protocol. Please refer to the subsequent pages for the approval of any facilities or focus areas requested. Approval comments on any proposed impact on City Health resources are also provided.

Please ensure the protocol has been followed for City staff to complete research and relevant line manager approval has been sought. Access to data request should be via Health information and technology - Mr Sibusiso Jali rather than via HIO.

Mitchells Plain & Southern:

Contact Person: Ms Jennifer Coetzee (Area South Manager)

Tel/Cell: 0824653339

Email: Jennifer.Coetzee@capetown.gov.za

Appendix D: Instructions for authors for the target journal – BMC Public Health

Link: https://bmcpublichealth.biomedcentral.com/submission-guidelines/preparing-yourmanuscript/research-article

Research article

Criteria

Research articles should report on original primary research or new experimental or computational methods, tests or procedures. Manuscripts reporting results of a clinical trial must conform to CONSORT 2010 guidelines. Authors of randomized controlled trials should submit a complete CONSORT checklist alongside their manuscript, available at www.consort-statement.org. Research articles may also report on systematic reviews of published research provided they adhere to the appropriate reporting guidelines which are detailed in our editorial policies.

Please note that non-commissioned pooled analyses of selected published research and bibliometric analyses will not be considered. Studies reporting descriptive results from a single institution or region will only be considered if analogous data have not been previously published in a peer reviewed journal and the conclusions provide distinct insights that are of relevance to a regional or international audience.

Data sharing

BMC Public Health strongly supports open research, including transparency and openness in reporting. Further details of our Data availability policy can be found on the journal's About page.

Professionally produced Visual Abstracts

BMC Public Health will consider visual abstracts. As an author submitting to the journal, you may wish to make use of services provided at Springer Nature for high quality and affordable visual abstracts where you are entitled to a 20% discount. Click here to find out more about the service, and your discount will automatically be applied when using this link.

Preparing your manuscript

The information below details the section headings that you should include in your manuscript and what information should be within each section.

Please note that your manuscript must include a 'Declarations' section including all of the subheadings (please see below for more information).

Title page

The title page should:

- present a title that includes, if appropriate, the study design e.g.:
    - "A versus B in the treatment of C: a randomized controlled trial", "X is a risk factor for Y: a case control study", "What is the impact of factor X on subject Y: A systematic review"
    - or for non-clinical or non-research studies a description of what the article reports
- list the full names and institutional addresses for all authors
    - if a collaboration group should be listed as an author, please list the Group name as an author. If you would like the names of the individual members of the Group to be searchable through their individual PubMed records, please include this information in the “Acknowledgements” section in accordance with the instructions below

- Large Language Models (LLMs), such as ChatGPT, do not currently satisfy our authorship criteria. Notably an attribution of authorship carries with it accountability for the work, which cannot be effectively applied to LLMs. Use of an LLM should be properly documented in the Methods section (and if a Methods section is not available, in a suitable alternative part) of the manuscript.

- indicate the corresponding author

Abstract

The Abstract should not exceed 350 words. Please minimize the use of abbreviations and do not cite references in the abstract. Reports of randomized controlled trials should follow the CONSORT extension for abstracts. The abstract must include the following separate sections:

- **Background**: the context and purpose of the study
- **Methods**: how the study was performed and statistical tests used
- **Results**: the main findings
- **Conclusions**: brief summary and potential implications
- **Trial registration**: If your article reports the results of a health care intervention on human participants, it must be registered in an appropriate registry and the registration number and date of registration should be stated in this section. If it was not registered prospectively (before enrollment of the first participant), you should include the words

'retrospectively registered'. See our editorial policies for more information on trial registration

Keywords

Three to ten keywords representing the main content of the article.

Background

The Background section should explain the background to the study, its aims, a summary of the existing literature and why this study was necessary or its contribution to the field.

Methods

The methods section should include:

- the aim, design and setting of the study
- the characteristics of participants or description of materials
- a clear description of all processes, interventions and comparisons. Generic drug names should generally be used. When proprietary brands are used in research, include the brand names in parentheses
- the type of statistical analysis used, including a power calculation if appropriate

Results

This should include the findings of the study including, if appropriate, results of statistical analysis which must be included either in the text or as tables and figures.

Discussion

This section should discuss the implications of the findings in context of existing research and highlight limitations of the study.

Conclusions

This should state clearly the main conclusions and provide an explanation of the importance and relevance of the study reported.

List of abbreviations

If abbreviations are used in the text they should be defined in the text at first use, and a list of abbreviations should be provided.

Declarations

All manuscripts must contain the following sections under the heading 'Declarations':

- Ethics approval and consent to participate
- Consent for publication
- Availability of data and materials
- Competing interests
- Funding
- Authors' contributions
- Acknowledgements
- Authors' information (optional)

Please see below for details on the information to be included in these sections.

If any of the sections are not relevant to your manuscript, please include the heading and write 'Not applicable' for that section.

Ethics approval and consent to participate

Manuscripts reporting studies involving human participants, human data or human tissue must:

- include a statement on ethics approval and consent (even where the need for approval was waived)

- include the name of the ethics committee that approved the study and the committee's reference number if appropriate

Studies involving animals must include a statement on ethics approval and for experimental studies involving client-owned animals, authors must also include a statement on informed consent from the client or owner.

See our editorial policies for more information.

If your manuscript does not report on or involve the use of any animal or human data or tissue, please state "Not applicable" in this section.

Consent for publication

If your manuscript contains any individual person's data in any form (including any individual details, images or videos), consent for publication must be obtained from that person, or in the case of children, their parent or legal guardian. All presentations of case reports must have consent for publication.

You can use your institutional consent form or our consent form if you prefer. You should not send the form to us on submission, but we may request to see a copy at any stage (including after publication).

See our editorial policies for more information on consent for publication.

If your manuscript does not contain data from any individual person, please state "Not applicable" in this section.

Availability of data and materials

All manuscripts must include an 'Availability of data and materials' statement. Data availability statements should include information on where data supporting the results

reported in the article can be found including, where applicable, hyperlinks to publicly archived datasets analysed or generated during the study. By data we mean the minimal dataset that would be necessary to interpret, replicate and build upon the findings reported in the article. We recognise it is not always possible to share research data publicly, for instance when individual privacy could be compromised, and in such instances data availability should still be stated in the manuscript along with any conditions for access.

Authors are also encouraged to preserve search strings on searchRxiv https://searchrxiv.org/, an archive to support researchers to report, store and share their searches consistently and to enable them to review and re-use existing searches.
searchRxiv enables researchers to obtain a digital object identifier (DOI) for their search, allowing it to be cited.

Data availability statements can take one of the following forms (or a combination of more than one if required for multiple datasets):

- The datasets generated and/or analysed during the current study are available in the [NAME] repository, [PERSISTENT WEB LINK TO DATASETS]
- The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
- All data generated or analysed during this study are included in this published article [and its supplementary information files].
- The datasets generated and/or analysed during the current study are not publicly available due [REASON WHY DATA ARE NOT PUBLIC] but are available from the corresponding author on reasonable request.

- Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.
- The data that support the findings of this study are available from [third party name] but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of [third party name].
- Not applicable. If your manuscript does not contain any data, please state 'Not applicable' in this section.

More examples of template data availability statements, which include examples of openly available and restricted access datasets, are available here.

BioMed Central strongly encourages the citation of any publicly available data on which the conclusions of the paper rely in the manuscript. Data citations should include a persistent identifier (such as a DOI) and should ideally be included in the reference list. Citations of datasets, when they appear in the reference list, should include the minimum information recommended by DataCite and follow journal style. Dataset identifiers including DOIs should be expressed as full URLs. For example:

Hao Z, AghaKouchak A, Nakhjiri N, Farahmand A. Global integrated drought monitoring and prediction system (GIDMaPS) data sets. figshare. 2014. http://dx.doi.org/10.6084/m9.figshare.853801

With the corresponding text in the Availability of data and materials statement:

The datasets generated during and/or analysed during the current study are available in the [NAME] repository, [PERSISTENT WEB LINK TO DATASETS].[Reference number]

If you wish to co-submit a data note describing your data to be published in BMC Research

Notes, you can do so by visiting our submission portal. Data notes support open data and help authors to comply with funder policies on data sharing. Co-published data notes will be linked to the research article the data support (example).

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All financial and non-financial competing interests must be declared in this section.

See our editorial policies for a full explanation of competing interests. If you are unsure whether you or any of your co-authors have a competing interest please contact the editorial office.

Please use the authors initials to refer to each authors' competing interests in this section.

If you do not have any competing interests, please state "The authors declare that they have no competing interests" in this section.

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Authors' contributions

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Acknowledgements

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hold at institutions or societies, or any other relevant background information. Please refer to authors using their initials. Note this section should not be used to describe any competing interests.

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Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

References

Examples of the Vancouver reference style are shown below.

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Web links and URLs: All web links and URLs, including links to the authors' own websites, should be given a reference number and included in the reference list rather than within the text of the manuscript. They should be provided in full, including both the title of the site and the URL, as well as the date the site was accessed, in the following format: The Mouse Tumor Biology Database. http://tumor.informatics.jax.org/mtbwi/index.do. Accessed 20 May 2013. If an author or group of authors can clearly be associated with a web link, such as for weblogs, then they should be included in the reference.

Example reference style:

Article within a journal

Smith JJ. The world of science. Am J Sci. 1999;36:234-5.

Article within a journal (no page numbers)

Rohrmann S, Overvad K, Bueno-de-Mesquita HB, Jakobsen MU, Egeberg R, Tjønneland A, et al. Meat consumption and mortality - results from the European Prospective Investigation into Cancer and Nutrition. BMC Medicine. 2013;11:63.

Article within a journal by DOI

Slifka MK, Whitton JL. Clinical implications of dysregulated cytokine production. Dig J Mol Med. 2000; doi:10.1007/s801090000086.

Article within a journal supplement

Frumin AM, Nussbaum J, Esposito M. Functional asplenia: demonstration of splenic activity by bone marrow scan. Blood 1979;59 Suppl 1:26-32.

Book chapter, or an article within a book

Wyllie AH, Kerr JFR, Currie AR. Cell death: the significance of apoptosis. In: Bourne GH, Danielli JF, Jeon KW, editors. International review of cytology. London: Academic; 1980. p. 251-306.

OnlineFirst chapter in a series (without a volume designation but with a DOI)

Saito Y, Hyuga H. Rate equation approaches to amplification of enantiomeric excess and chiral symmetry breaking. Top Curr Chem. 2007. doi:10.1007/128_2006_108.

Complete book, authored

Blenkinsopp A, Paxton P. Symptoms in the pharmacy: a guide to the management of common illness. 3rd ed. Oxford: Blackwell Science; 1998.

Online document

Doe J. Title of subordinate document. In: The dictionary of substances and their effects. Royal Society of Chemistry. 1999. http://www.rsc.org/dose/title of subordinate document. Accessed 15 Jan 1999.

Online database

Healthwise Knowledgebase. US Pharmacopeia, Rockville. 1998. http://www.healthwise.org. Accessed 21 Sept 1998.

Supplementary material/private homepage

Doe J. Title of supplementary material. 2000. http://www.privatehomepage.com. Accessed 22 Feb 2000.

University site

Doe, J: Title of preprint. http://www.uni-heidelberg.de/mydata.html (1999). Accessed 25 Dec 1999.

FTP site

Doe, J: Trivial HTTP, RFC2169. ftp://ftp.isi.edu/in-notes/rfc2169.txt (1999). Accessed 12 Nov 1999.

Organization site

ISSN International Centre: The ISSN register. http://www.issn.org (2006). Accessed 20 Feb 2007.

Dataset with persistent identifier

Zheng L-Y, Guo X-S, He B, Sun L-J, Peng Y, Dong S-S, et al. Genome data from sweet and grain sorghum (Sorghum bicolor). GigaScience Database.
2011. http://dx.doi.org/10.5524/100012.

Figures, tables and additional files

See General formatting guidelines for information on how to format figures, tables and additional files.

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Back to top

When preparing figures, please follow the formatting instructions below.

- Figures should be numbered in the order they are first mentioned in the text, and uploaded in this order. Multi-panel figures (those with parts a, b, c, d etc.) should be submitted as a single composite file that contains all parts of the figure.
- Figures should be uploaded in the correct orientation.
- Figure titles (max 15 words) and legends (max 300 words) should be provided in the main manuscript, not in the graphic file.
- Figure keys should be incorporated into the graphic, not into the legend of the figure.
- Each figure should be closely cropped to minimize the amount of white space surrounding the illustration. Cropping figures improves accuracy when placing the figure in combination with other elements when the accepted manuscript is prepared for publication on our site. For more information on individual figure file formats, see our detailed instructions.

- Individual figure files should not exceed 10 MB. If a suitable format is chosen, this file size is adequate for extremely high quality figures.
- **Please note that it is the responsibility of the author(s) to obtain permission from the copyright holder to reproduce figures (or tables) that have previously been published elsewhere.** In order for all figures to be open access, authors must have permission from the rights holder if they wish to include images that have been published elsewhere in non-open access journals. Permission should be indicated in the figure legend, and the original source included in the reference list.

Figure file types

We accept the following file formats for figures:

- EPS (suitable for diagrams and/or images)
- PDF (suitable for diagrams and/or images)
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- PowerPoint (suitable for diagrams and/or images, figures must be a single page)
- TIFF (suitable for images)
- JPEG (suitable for photographic images, less suitable for graphical images)
- PNG (suitable for images)
- BMP (suitable for images)
- CDX (ChemDraw - suitable for molecular structures)

For information and suggestions of suitable file formats for specific figure types, please see our author academy.

Figure size and resolution

Figures are resized during publication of the final full text and PDF versions to conform to the

BioMed Central standard dimensions, which are detailed below.

Figures on the web:

- width of 600 pixels (standard), 1200 pixels (high resolution).

Figures in the final PDF version:

- width of 85 mm for half page width figure
- width of 170 mm for full page width figure
- maximum height of 225 mm for figure and legend
- image resolution of approximately 300 dpi (dots per inch) at the final size

Figures should be designed such that all information, including text, is legible at these dimensions. All lines should be wider than 0.25 pt when constrained to standard figure widths. All fonts must be embedded.

Figure file compression

- Vector figures should if possible be submitted as PDF files, which are usually more compact than EPS files.
- TIFF files should be saved with LZW compression, which is lossless (decreases file size without decreasing quality) in order to minimize upload time.
- JPEG files should be saved at maximum quality.
- Conversion of images between file types (especially lossy formats such as JPEG) should be kept to a minimum to avoid degradation of quality

If you have any questions or are experiencing a problem with figures, please contact the customer service team at info@biomedcentral.com.