Disposable diaper use and perception of health and environmental risks in a rural community from Bushbuckridge, South Africa

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Declaration

I hereby declare that this dissertation, which I hereby submit for the Master of Science degree in the Department of Veterinary Tropical Diseases, Faculty of Veterinary Science, University of Pretoria, to be my own work and has not been previously submitted by me for degree purposes at another tertiary institution.

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Amy Lowe

Date:

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In order of appearance:

- **SAP:** Superabsorbent polymers
- **MSW:** Municipal solid waste
- **LCA:** Life cycle assessment
- **EPEC:** Enteropathogenic *E. coli*
- **TBT:** Tributyltin
- **EPR:** Extended producer responsibility
- **FGD:** Focus group discussion
- **EM:** Environmental monitor
- **PPE:** Personal protective equipment
- **AHP:** Absorbent hygiene product

Summary

Littering of disposable diapers is a problem with One Health implications and has been identified as an issue within the Mnisi community, a rural area within Bushbuckridge, South Africa. Several environmental and public health related concerns arise from this, including contamination of waterways used by animals and people with human waste, scavenging by domestic and wild animals, and the aesthetic impact on the environment. The aim of this study was to gain an understanding of the use and sanitation practices associated with disposable diapers, with the ultimate goal of identifying possible community-led initiatives and solutions which can be used for training and education. Focus group discussions were conducted within the community which included a participatory mapping exercise used to map general diaper disposal sites. Focus group data was analyzed according to three themes: decisions and factors around diaper use and disposal, perceptions of impact and health risk of diaper use for people and animals, and barriers and solutions for proper disposal. Most participants used disposable diapers and disposed of them within the environment because they lacked access to municipal waste collection. Regarding decisions around diaper use, common factors discussed were convenience, social perception and beliefs, cost, water access, and diaper disposal logistics. Convenience and societal perception and beliefs were determined as key factors behind diapering choices, and both a gender and a generational divide was revealed. Participants express general understanding of negative impacts associated with diaper disposal, but knowledge gaps exist, notably regarding water pollution and pathogen spread, that could be a focus of educational campaigns. Regarding solutions, participants proposed the provision of a central collection point as well a return to reusable diapers, each of which has its own considerations and hurdles. Any interventions should retain the perceived convenience factor of disposable diapers and be implemented on a community rather than individual basis. Solutions should be multifaceted, involve opportunities for community collaboration amongst all ages and genders, and should also engage local leadership. Focus groups should be considered as the first steps towards continued discussions amongst stakeholders.

1. Introduction

Disposable diaper use has increased dramatically worldwide. In resource limited communities waste management infrastructure is frequently minimal to nonexistent, and used diapers are commonly disposed of within the environment. Several environmental and public health-related concerns arise from this which fit into a One Health framework, including contamination of waterways used by animals and people with human waste, scavenging by domestic and wild animals, and accumulation of plastic waste and its aesthetic impact on the environment.

Littering of disposable diapers in the environment has previously been identified as a concern within the Mnisi community in the Bushbuckridge municipality of South Africa, a resource-poor area in which residents have strong links with agriculture and livestock and which borders conservation areas (Berrian et al, 2016). There is no reliable municipal waste collection in the community (Kordecki et al, 2022), although there is access to recycling to a limited extent (personal communication, IVW). A previous exploratory study undertaken within the Mnisi area utilized community engaged approaches to collect information on demographics, human and animal health priorities, and perceptions on environmental health (Berrian et al, 2016). This study was the first to characterize disposable diaper use within the Mnisi community and revealed that 80% of households with a young child reported using disposable diapers, and found that they were mostly disposed of in the environment or burned. It was mentioned that the frequency of disposal in the environment is likely to increase and recommended future research on waste disposal. Kordecki et al (2022) mapped diaper waste sites within the Kruger 2 Canyons biosphere region, which includes Mnisi communal area and other small towns, and found that diaper waste sites were commonly located close to human dwellings, alongside roadways, rivers, and animal grazing sites. However, the authors did not investigate the reasons why disposable diapers are preferred over reusable options, theorizing that convenience factors and water access may play a role. Further research into economic, social and cultural factors associated with diaper use and disposal was recommended. While

littering of diapers has been identified as a concern, it is necessary to gain a better understanding of current diapering and disposal preferences within this community in order to investigate contextually appropriate solutions, as well as target resources to problem sites.

1.1 Aims

Our study aimed to gain an understanding of current drivers behind the use and sanitation practices associated with disposable diapers within the Mnisi area, with the ultimate goal of identifying possible community-led initiatives and solutions which can be used for training and education, and engaging relevant stakeholders in creating sustainable solutions.

1.2 Objectives

- Describe diaper use and disposal practices, including socio economic and cultural drivers behind decision making, within the Mnisi community
- Identify knowledge gaps surrounding potential and perceived health risks associated with diaper disposal, in terms of human, animal and environmental impacts
- Identify potential community-led solutions to the problem of environmental pollution of disposable diapers

2. Literature Review

2.1 Disposable diaper use worldwide

There is significant variability in baby diapering practices around the world, influenced by the social and family environment of the mother, as well as socioeconomic status and cultural norms (Aishwarya & Priyanka, 2020; Thaman & Eichenfield, 2014). One time use products are becoming integrated into daily life. The use of disposable diapers has increased dramatically worldwide, becoming the predominant form used within developing countries in recent years. The preference for disposable diapers over reusable diapers has been found to largely relate to convenience factors, namely the time saved from having to wash and dry reusable diapers, as well as ease of use. Hygiene factors, such as better moisture absorption and leak protection, have also contributed to the popularity of disposable diapers, along with the need for water conservation in periods of drought (Dey et al, 2015; Krafchik, 2016; Jesca & Junior, 2015; Ntekpe et al, 2020; Wambui et al, 2015; Joseph, & Makindi, 2015; Remigios, 2014). While once considered a luxury item in many developing countries, to be used mostly for travel and special occasions, disposable diapers have overwhelmingly replaced the use of reusable or cloth diapers (Jesca & Junior, 2015). Within Africa, 78% of study respondents in Zimbabwe (Jesca & Junior, 2015) and 86% in Kenya (Muia, 2018) reported using disposables exclusively. Although a study by Muia (2018) in Kenya demonstrated a statistically significant correlation between education level and the choice to use disposable diapers, in most other studies reviewed, mothers preferred to use disposable diapers irrespective of their education level, socioeconomic status, employment status, or age (Remigios, 2014; Wambui et al, 2015). Disposable diapers have become a symbol of “prosperity and complexity, affluence and sophistication,” a fashionable status symbol (Magadza, 2016), and are considered an indispensable tool for modern life (Remigios, 2014).

Worldwide, the production of diapers is a multi-billion dollar industry (Perez et al, 2020). In Bangladesh, it is estimated that the diaper market is growing by more than 40% per year (Rahat et al, 2014); while in Japan, the volume of diapers produced has doubled since 2010 (Itsubo et al, 2020). Disposable diapers have been introduced relatively recently to the African continent

and their use has increased steadily with the growing diaper market (Wambui et al, 2015). Within South Africa it is estimated that more than 4 billion disposable diapers are sold annually (Aishwarya & Priyanka, 2020). Disposable diapers are highly accessible for consumers, even in rural areas where they can be easily obtained in supermarkets and tuck shops (Magadza, 2016). Similar to other commodities, the huge demand has led to increased supply in the market (Remigios, 2014; Wambui et al, 2015). With increasing population, urbanization, and an expanding middle class allowing for higher disposable income in developing countries, the demand for diapers is expected to continue to increase (Ali et al; Magadza, 2016). Manufacturers are eager to capitalize on this growing economy, and the profit potential likely outweighs consideration for environmental impacts. This growing demand means countries will continue to spend money importing these products that ultimately end up contributing to pollution and solid waste buildup within their borders (Magadza, 2016).

2.2 Disposable diaper waste management worldwide

Ultimately, disposable diapers contribute to large quantities of waste because they are non-biodegradable, and their degradation is a slow process. Disposable diapers have been estimated to make up between 1-4% of the world's non-biodegradable waste (Krafchik, 2016; Ntekpe et al, 2020), with an estimated 18 billion diapers reaching landfills annually (Aiswarya & Priyanka, 2020). Estimates are that a single child will be changed between 3500-7500 times before they are toilet trained (Dey et al, 2015; Ali et al, 2017), and the superabsorbent polymers (SAP) within disposable diapers absorb more than 30 times its weight (Dey et al, 2015). Used diapers will overwhelmingly end up in landfills worldwide and make up a significant proportion of non-biodegradable municipal solid waste (MSW) produced from residential areas and households (Wambui et al, 2015), which contributes to reduction of a landfill's lifespan (Mathe, 2018). In Kuala Lumpur, one study estimated that disposable diapers made up over 14% of MSW by weight in 2016, which was equal to approximately 500 tonnes of diapers per day - this was up from 5% of MSW in 2001 (Ali et al, 2017).

Research into problems associated with disposables on the African continent is lacking. As Magadza (2016) describes, it is "a visible problem that has not yet been addressed". In

developing countries, waste management infrastructure is commonly minimal to nonexistent, as previously described in studies from Kenya (Wambui et al, 2015), Nigeria (Ntekpe et al, 2020) and Zimbabwe (Magadza, 2016; Mathe, 2018). Therefore, users of these products are frequently responsible for figuring out how to dispose of the diapers after use, and littering of diapers in the environment is commonplace. Methods employed for disposal include burning, burying in the ground, throwing in a pit latrine, dumping in open spaces (e.g., bushes, roadside, or veld) either freely or inside a plastic bag, placing in refuse bins where available, and establishment of illegal dumping sites (Muia, 2018; Wambui et al, 2015; Remigios, 2014; Nyamayedenga & Tsvere, 2020). Additionally, these dumping sites can be in close proximity to households (Kordecki et al, 2022; Remigios, 2014). Disposing of diapers in this way causes concern not just for the communities currently living with this issue, but also because disposable diapers can take 400-1000 years to break down (Remigios, 2014; Wambui et al, 2015), so the effects may be seen for multiple generations to come.

It is a widespread assumption that local municipal authorities are responsible for improving waste management; however, governmental agencies in two areas in Zimbabwe self-reported to be insufficiently funded and lacking the power to effectively make changes (Jesca & Junior, 2015; Nyamayedenga & Tsvere, 2020). Mnisi (2011) discusses that within South Africa, government funding for sanitation programs is often of low priority. Remigios (2014) discusses that in the suburb of Gweru, Zimbabwe, conversations with the municipal government agencies tasked with waste disposal revealed a lack of capital available to implement waste management systems, such as the provision and pickup of refuse bins, leading to unreliable service delivery. Even when residents in Zimbabwe deposited diapers into refuse bins, erratic collection resulted in continued disposal of the diapers in the environment when the bins were full (Jesca & Junior, 2015). Magadza (2016) found that in an urban area of Zimbabwe, mothers reported that if diapers were not separated into sealed bags and instead combined with other household waste, municipal waste services would not pick it up. Nyamayedenga & Tsvere (2020) describe a fragmented system where relevant stakeholders, such as residents, local city councils, and the government, do not work together to create integrated waste management. Instead, they lay blame on each other, resulting in no progress towards improvement of the systems.

2.3 Health and environmental effects associated with disposable diapers

There are environmental impacts generated from the production of disposable diapers, related to the use of raw materials including trees, energy input, fossil fuel consumption from the production of plastic and transport of the finished products, and pollution associated with toxic chemicals (Aishwarya & Priyanka, 2020; Perez et al, 2020). Disposable diapers contain potentially toxic chemicals, microplastics and other harmful substances, including dioxins, sodium polyacrylate, tributyltin (TBT) and phthalates, which can leach into the environment (Aishwarya & Priyanka, 2020; Ali et al, 2017; Wambui et al , 2015) and be released into the air when burned, causing respiratory tract irritation and exacerbation of underlying respiratory illnesses (Jesca & Junior, 2015). The breakdown and burning of diapers also contributes to the production of greenhouse gasses, contributing to ozone depletion and global warming (Perez et al, 2020), and the ash generated by burning can be carried long distances by the wind (Jesca & Junior, 2015; Ntekpe et al, 2020; Rahat et al, 2014). Even after burning, not all of the diaper is consumed, leaving particles within the environment that may have an effect on agriculture (Remigios, 2014).

Littering of disposable diapers causes many issues for the environment and poses health risks for people and animals, contributing to pollution of air, water and soil. Concerns surrounding disposal of diapers within the environment arise from the human excreta contained within the diaper, as well as with materials making up the diaper itself. Life cycle assessments (LCAs) looking at environmental impact tend to assume diapers are ending up in landfills and/or eventually being incinerated, so environmental dumping in these cases increases the impact of disposables tremendously (Perez et al, 2020).

Accumulation of used disposable diapers containing human waste in the environment leads to the spread of pathogens, which can persist within the fecal matter in the environment for long periods of time (Aishwarya & Priyanka, 2020; Morita et al, 2016). Human feces may harbour various pathogenic bacteria,viruses, parasites, and protozoa, potentially spreading diseases such as cholera and typhoid (Perez et al, 2020; Ntekpe et al, 2020). Children's stool, and especially infants under the age of 1 year, tends to contain higher levels of pathogens than

adult stool, leading to significant environmental contamination (Ntekpe et al, 2020). Nyamayendega & Tsvere (2020) note that even when diapers do reach landfills in developing countries, they are often unlined, meaning contamination of surface and groundwater can still occur. Additionally, waste pickers can be inadvertently exposed to human fecal matter (Magadza, 2016; Ntekpe et al, 2020). Pathogen spread can cause detrimental effects on underground water sources, potentially leading to contamination of drinking water for humans, domestic animals and wildlife (Ntekpe et al, 2020; Remigios, 2014). Contaminated drinking water is a significant exposure source for diarrheal pathogens such as Salmonella and Shigella, and once introduced into a water source, such as a river, these pathogens may remain viable for prolonged periods of time and can be carried long distances (Julian, 2016; Ntekpe et al, 2020). Diarrheal diseases cause significant morbidity in children, with an estimated 1.7 billion cases of gastrointestinal disease yearly in children under the age of five (Julian, 2016). These diseases can also be associated with malnutrition and impaired growth or stunting, which may lead to reduced performance later in life (Julian, 2016; Morita et al, 2016). Furthermore, some diarrheal pathogens such as enteropathogenic *E. coli* (EPEC) and cryptosporidium are reverse zoonoses, infecting domestic animals (e.g.,dogs and cattle) and possibly cycling amongst animals and people through exposure to feces (Julian, 2016).

Diapers disposed of in sewers, toilets or waterways can cause physical blockage of drains and interruptions to the water supply. Residents in Zimbabwe have stated that disposable diapers were the most common cause of sewer blockages and bursts (Remigios, 2014). Domestic animals may also scatter diapers around the environment and possibly ingest them, leading to health issues (Ntekpe et al, 2020; Remigios, 2014). Areas where diapers accumulate in the environment may attract flies and other insects, which can act as biological or mechanical vectors for pathogens (Julian, 2016; Remigios, 2014). There are also negative aesthetic impacts on the environment, and disposal sites are generally unpleasant, with residents in one study complaining of the smell that can arise (Remigios, 2014).

2.4 Potential Solutions

To encourage consumers to take ownership and drive changes, there must be appropriate and accessible disposal solutions available for end users of diapers. In Zimbabwe, a study found that mothers were aware that littering of disposable diapers in the environment was illegal and wrong, but they stated that there were no other acceptable disposal options available to them (Remigios, 2014). A study based in Kenya found that respondents had a poor understanding of the environmental effects of unsafe diaper disposal, with education level being positively correlated with awareness of the risks (Muai, 2018). Many studies recommend education and awareness campaigns, as well as sensitization on appropriate methods for diaper disposal, positing that such educational campaigns on the negative impacts associated with diaper disposal may lead to behavioural changes (Ntekpe et al, 2020; Nyamayedenga & Tsvere, 2020; Wambui et al, 2015). However, in a study on diapering preferences within Dhaka City in Bangladesh (Rahat et al, 2014), 80% of respondents reported that they knew disposable diapers are harmful to the environment, but 87% of respondents still preferred to use them.

Some studies have recommended a return to reusable diapers, with possible financial incentivization from the government, as well as taxes on disposable diapers. The revenue generated from such taxes could then be directed towards programs focused on educating the public and implementing proper disposal programs (Remigios, 2014). Previous legislative attempts to reduce the use of disposable diapers have had varying success, and the country of Vanuatu has gone as far as to ban their use (Mcveigh, 2019; Perez et al, 2020). Discussions around the return to reusable diapers have highlighted ways to make them more convenient for mothers, such as more convenient shapes and absorbable inserts, as well as access to laundering services similar to those already available in many developed countries (Magadza, 2016). Transitioning back to reusable diapers is commonly proposed as an environmentally friendly solution, but it must be noted that their production and use also involve significant energy and water consumption, as summarized in a paper by Magadza (2016). While energy impacts associated with disposable diapers result primarily from their production and disposal, energy impacts from reusables result from water and energy consumption associated with their use. However much of the energy use is associated with electric washing machines and dryers

(Aishwarya & Priyanka, 2016), so in rural areas of developing countries where diapers are laundered by hand and hung outside to dry, energy impacts are likely considerably lower.

Solutions for more sustainable disposable diaper waste management range from the seemingly simple to complex, from the implementation of novel governmental policies, to manufacturing changes using more biodegradable materials, to advanced technologies for recycling and energy reclaiming. While it is outside the scope of this review to present all possible novel solutions for diaper waste, it is interesting to mention the technologies that are being investigated and may be available in the future. Innovations and improvements in diaper design have already reduced the size and weight of disposable diapers drastically since their first use, and there is additional improvement potential which will undoubtedly reduce their physical size even more (Cordella et al, 2015; Krafchik, 2016; Perez et al, 2020). With energy reclaiming technologies becoming available, when the landfill is the ultimate end point for diaper disposal, communities are not only negatively affected by the piling up of diapers, but miss out on energy reclaiming or reuse of materials, where resources and energy have already gone into their manufacture (Ali et al, 2017). A study based in Lahore, Pakistan investigated the potential for using MSW for energy recapture - the combustible fraction, which included diapers, comprised 81% of the total waste amount (Azam et al, 2020). Therefore, if technology allowed, used disposable diapers could become a viable part of waste-to-energy production. Accordingly, in countries such as Japan where waste management systems are highly effective and the vast majority of diapers are incinerated in government facilities along with other domestic waste and contribute to energy recapture, the focus is now directed towards more efficient energy recapture and closed-loop recycling (Ali et al, 2017; Itsubo et al, 2020). Similarly in Europe, companies such as Knowaste have developed highly specialized technologies that allow recycling of diapers to produce energy and other materials such as cat litter (Magadza, 2016; Plotka-Wasylka et al, 2022). These technologies have been shown to drastically reduce the ecological footprint of disposable diapers. Similarly, composting the biodegradable parts of the diapers has been discussed as a promising solution (Colon et al, 2011; Ferronato et al, 2020; Rahat et al, 2014), which, similar to energy recapture, would provide a positive benefit to the community in terms of compost that could be used in agriculture. Other methods for the

reduction of mass associated with diaper waste are being tested and in some cases implemented (Colon et al, 2011). Many of these solutions require a combination of high human, financial, and infrastructural capital to implement and sustain, and various factors make their use less feasible in many developing countries where waste infrastructure is primitive. However, the phenomenon of technology leapfrogging in Africa – an example being countries moving directly to mobile phone usage instead of investing in landline infrastructure – means technologies fine-tuned in other countries may be directly employed in certain areas. All new technologies being investigated will ultimately require some level of separation and collection of disposable diapers, something which is not currently happening. Therefore, the priority for now should be directed towards the initial steps of separating diapers, possibly through establishing a centralized collection system. Wambui et al (2015) found that only 20% of participants were willing to take diapers to a central collection centre, though a slightly higher percentage indicated they would be more willing to do so if provided monetary incentives.

As discussed, the complex landscape of politics, socioeconomics, and other factors precludes access to even basic household waste management in many developing countries, so improvements to waste management systems should be based not just on new technologies, but also focus on systemic changes. Whatever the solution, it must take into account local context and current realities. Nyamayedenga & Tsvere (2020) highlighted the importance of understanding the current diaper waste context, stating that "if knowledge is power then a city without knowledge of its solid waste system may lack the power to make positive changes," and emphasized that real-time data capture, involving community members and citizens, can provide rich information that stakeholders can use in implementing solutions. With governments underfunded and historically unable to facilitate efficient waste management services, it may be prudent to prioritize public-private partnerships by involving community members and other key stakeholders in identifying potential solutions (Jesca & Junior, 2015).

Extended producer responsibility (EPR) programs have been in place in some contexts since the 1980s and aim to have manufacturers assume responsibility for environmental impacts of their products (Perez et al, 2020). Some stakeholders including environmental lobbyists insist on corporate responsibility in acknowledging the LCA of disposable diapers and providing

solutions to create a closed system, possibly focusing on the use of more biodegradable materials (Perez et al, 2020). Aishwarya & Priyanka (2020) describe various brands of diapers currently available which are produced from bio-based materials such as bamboo, organic cotton and corn, some of which are compostable and/or biodegradable within the environment. However, Magadza (2016) found that the current production of bioplastic-based disposable diapers or using bio-based SAP made from renewable and biodegradable materials actually had higher environmental impacts associated with sourcing the materials. Perez et al (2020) discuss that the few manufacturers benefiting from the huge diaper market should take charge in the research and development of environmentally sustainable products and engage with stakeholders to continue moving towards reduction of environmental impacts. Moreover, Cordella et al (2015) also suggest that research should continue to focus not just on how to dispose of current diapers, but also on how to make them more environmentally friendly, as it is not only their disposal but their production that has ecological impacts. Novel solutions may come from the communities themselves - a group of women in Zimbabwe used locally sourced cotton materials to make diapers which are more biodegradable (Magadza, 2016).

3. Materials and Methods

3.1 Study Area

This study took place within 2 villages within the Mnisi community, which is situated within the north-eastern corner of the Bushbuckridge Municipal Area, Mpumalanga Province, South Africa. The total population in the Mnisi study area is about 40,000 and Shangaan is the primary language spoken. The community has a long-standing research partnership with the University of Pretoria through the Mnisi Community Programme, which facilitates community-based research and capacity building within this resource-poor area, in which residents rely on agriculture and other natural resources for economic sustainability (Berrian et al, 2016). Much of the land directly borders provincial and private game reserves, such as Kruger National Park, which form part of the Greater Limpopo Transfrontier Conservation Area (GLTFCA) (Simpson et al, 2018).

3.2 Data Collection

Data was collected through a series of focus group discussions (FGDs) held within the Mnisi community. The FGDs were intended to explore perceptions and attitudes towards gender roles and social variables that influence diapering choices and disposal, perceived health risks, and potential community-level solutions to reduce environmental disposable diaper waste.

The FGDs took place in three distinct locations situated within two separate villages in the Mnisi area - the community center in Share village, and the Hluvukani State Veterinary Building and Keepwell creche facility in Eglinton. At the beginning of each FGD, verbal consent was obtained from all participants to record and take photos. Focus group discussions were conducted in April 2022 across six distinct participant groups: (i) younger women (under 35 years of age); (ii) older women (aged 35 years and above); (iii) younger men (under 35 years of age); (iv) older men (aged 35 years and above); (v) creche workers (daycare); and (vi) elders and induna (i.e. tribal authority or headman of the village). The FGDs were carried out

independently for each of the groups listed, except for the younger and older men cohorts, due to scheduling constraints.

Figure 3.1 Left: Focus group discussion being conducted with group of elders and induna, Right: Creche workers doing participatory mapping exercise

Participants were recruited within each village by environmental monitors (EMs), which are community liaisons involved with the Mnisi Community Programme, based on availability when focus groups were conducted. The size of the focus groups ranged from 3 to 11 individuals (mean=7), yielding a total of 44 participants (41% women, 59% men) (Table 1). The ages of participants engaged in the FGDs ranged from 18 to 61 years (mean=34); however, age data was not recorded for late arrivals or members of the elders and induna group. All FGD participants reported having children and/or grandchildren, except for four individuals in the younger men's group. All the older men reported keeping livestock.

Table 3.1 *Participant demographics for the focus group discussions.*

	Younger women (<35)	**Older women (>35)**	**Younger men (<35)**	**Older men (>35)**	**Creche workers**	**Elders and induna**
Group size	6	5	10	9	3	11
Gender	F	F	M	M	F	M (7)/F (4)
Age range	21-33	32-40	18-29	52-61	39-46	Not available
Location	Community centre	Community centre	Hluvukani State Veterinary building	Hluvukani State Veterinary building	Keepwell creche	Community centre
Village	Share	Share	Eglinton	Eglinton	Eglinton	Share

Focus group discussions started with a participatory mapping exercise in which participants worked together to create a general map of their community, indicating waterways, animal grazing areas and diaper disposal sites using coloured paper. A semi-structured questionnaire was then used to guide the discussion while allowing participants to provide answers to open-ended questions (Appendix A). Questions focused on disposal sites for nappies in the environment (4 questions), methods for disposal (2 questions), risks for different methods of disposal (3 questions), challenges and solutions around disposal (3 questions) and use of reusable nappies (1). Demographic information included questions on age and whether participants have children or grandchildren. Participants commonly referred to disposable diapers as Pampers and reusable diapers as nappies or napkins.

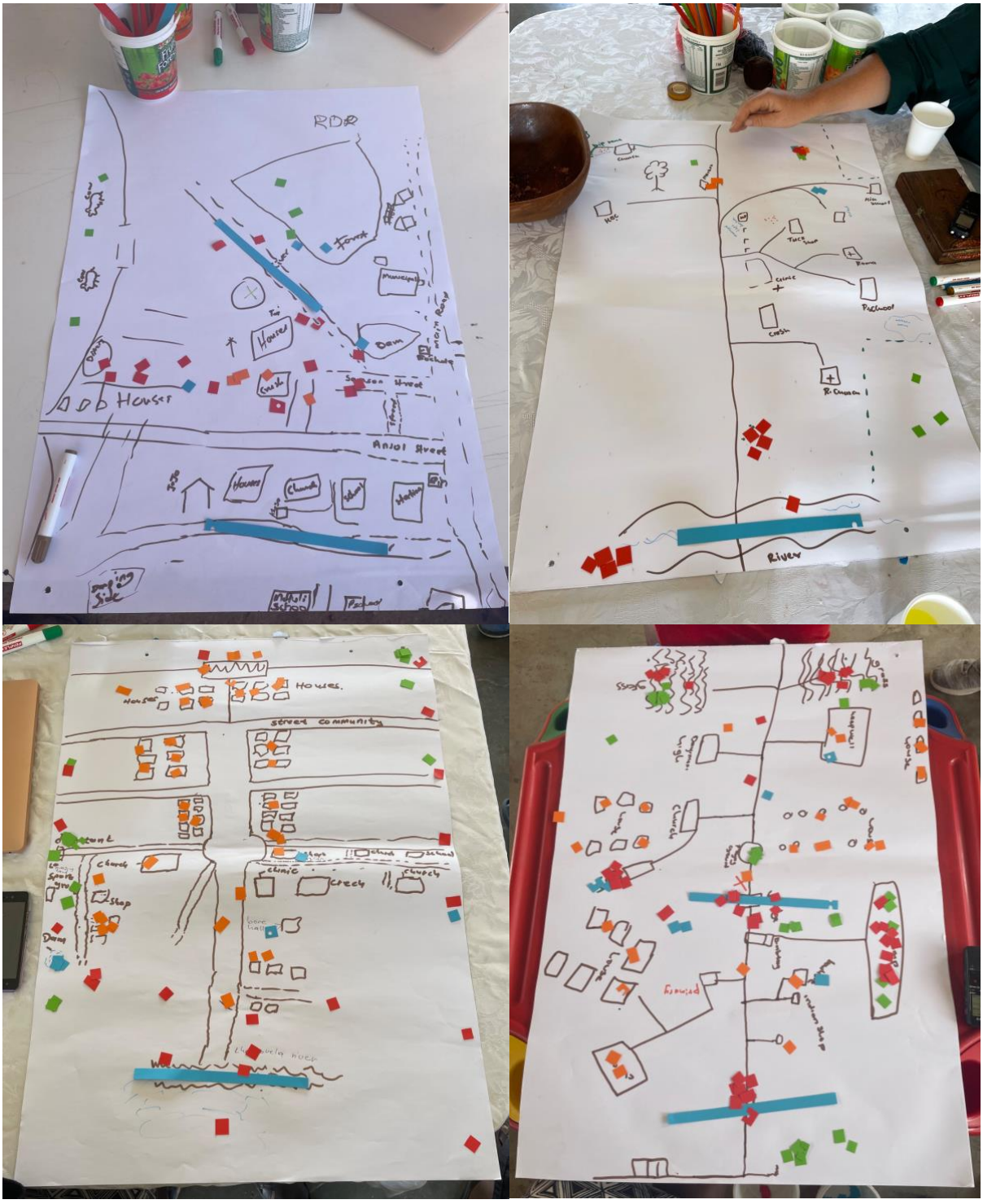

Figure 3.2 *Maps created during participatory mapping exercise (clockwise from top left): Younger and Older men, Young women, Creche workers, Elders and indunas. Blue = rivers and other water sources; Green = animal grazing sites; Orange and red = diaper disposal sites*

The majority of participants spoke in their local language, Shangaan, during the FGDs, with some participants answering questions in English. Therefore, the study investigators led the discussions with the aid of an EM who acted as a facilitator and translator and whose gender matched that of the group. The participants' responses were translated from Shangaan to English in real time for the facilitators. The discussions were also audio recorded using a Dictaphone and subsequently transcribed in English by the study investigator (AL). There was no remuneration provided for participation in the FGDs; however, light refreshments were provided to each group after the discussions concluded. After the FGD in two locations (creche and young women), the participants walked the study investigators around the village to demonstrate areas where diapers were being disposed of in the environment. The study investigators also drove around the communities to survey for sites of diaper accumulation.

Figure 3.3 *Photos taken while walking through community demonstrating disposable diaper accumulation within the environment*

3.3 Data Analysis

The FGD transcripts, including participants' comments and responses, were analyzed by the research team to identify common perspectives, sentiments, and patterns that were recurrent across the different participant groups. The qualitative data was then coded and organized according to identified themes, and sub-themes when appropriate, to form a descriptive narrative.

3.4 Ethics Statement

This study was approved by the Research Ethics Committees of the Faculty of Health Sciences (REC154-20) and the Faculty of Humanities (96042878, HUM006/0122), University of Pretoria.

4. Results

Three key themes were identified based on our qualitative analysis. The first theme comprised decisions and factors around diaper use and disposal practices and was further divided into five different factors. Theme two centered around perceptions of the impacts and health risks associated with disposable diaper pollution on people, animals, and the environment. The third theme identified included barriers and potential solutions for proper disposal of diapers.

Theme 1: Decisions and factors around diaper use and disposal practices

Under this theme, the following five factors associated with diaper use and disposal practices were commonly discussed across the different focus groups: convenience, social perceptions and beliefs, cost, water access, and diaper disposal logistics.

Factor 1. Convenience

Participants in the younger women and creche groups commonly cited convenience-related factors, such as lack of time and busy schedules, as influencing their decision to use disposable diapers. These participants expressed that they *"don't have time to wash"* and that *"Pampers is simple"*. However, the older participants in the focus groups expressed the view that the use of disposable diapers was mainly due to laziness among the younger generation of mothers, rather than busy lifestyles: *"They are lazy. The moms for nowadays are very lazy to wash."* Interestingly, one younger woman (<35 years old) also contradicted the idea that there is no time to wash, stating that *"It's not that we are all busy, it's because we are all lazy. Everyone nowadays who are using the diapers, we are lazy, that is it. Even if you are not going anywhere, you are always busy."*

Since laundry and washing are typically done outdoors within the villages, environmental conditions were also mentioned as influencing diaper choice. Participants noted the difficulty

with washing cloth diapers during cold or rainy weather, which has led to an increased demand for disposable options. As a creche worker stated, *"but it's simple, the Pampers, that one it's cold you can't wash and it's raining you can't wash, that's why they need the nappies".* Additionally, the ease of accessing disposable diapers was also identified as a contributing factor. A participant from the elders and indunas group stated that *"They can't stop to buy* [disposable diapers]*, meanwhile they are there at the shop."*

Factor 2. Social perceptions and beliefs

Societal pressures and norms also influenced decisions around diaper usage within the Mnisi community. The young and older men's group commented that using disposable diapers was seen as more fashionable and trendy, suggesting that women who use reusable diapers may be perceived as being behind the times. One participant remarked: *"The problem is one – it's a matter of fashion. Because everybody wants to be in front when it comes to fashion. Nobody doesn't want to be behind"* and *"Yeah, it's cool for them because of the fashion."*

The young and older men's group also suggested a divide between elders and younger people within the community, with the elders preferring the traditional reusable diapers, while the younger generation favoured the more modern disposable options. One participant stated, *"But the elder people, they want to use the ones that they grown with. And the new people they want to go with their generation."* Regarding reusable diapers, an older woman also mentioned that if the diapers were not perfectly clean, *"people will laugh at you because it is pure white."* When the women were asked a follow-up question about whether they would use reusable diapers if they were available in different colours, all participants said that *"if they were different colours, they wouldn't mind washing them and using them."*

Another societal belief that emerged was the fear that witch doctors could cause harm to children if they obtained the used diapers. A participant in the elders and induna group stated, *"we as black people, we don't want someone to take our child's used diapers, that sometimes we think of witchcraft."* In the creche group it was mentioned that some mothers request to take their child's used diapers home so they can dispose of them there. Participants also stated

that even when volunteers previously collected the used diapers, some people refused to give them, due to concerns about witchcraft. However, some participants also noted that this belief might be outdated, as they had not witnessed any actual harm to children, even with the widespread environmental accumulation of disposable diapers. As an older woman summarized, *"We can't say it's not true because our beliefs is not the same. So it depends on how you believe. But we grow up they tell us about that. But now what I think, it was for long time ago, because now you can see that the diapers are everywhere and the witch doctors don't take it because all kids are still living, so I can say that I don't believe it, because our kids are happy and we are just throwing* [the disposable diapers] *everywhere."*

Factor 3. Cost

There were conflicting comments on the relative cost of reusable versus disposable diapers and how this would factor into decisions around diaper usage. A participant from the young and older men's group suggested that disposable diapers are more expensive in the long run, as reusable diapers can be used for multiple children: *"If you can check the money that they spend from the Pampers, and the cloth one, the Pampers is more expensive, because the cloth one you can use it for the first born, the second born, and also if they are not having holes or whatever then you can use it for the rest of our births."* A creche worker suggested that even if disposable diapers are more expensive, the convenience factor is more important, stating *"Yeah, it is a lot of money, but it's simple, the Pampers."*

However, a participant in the elders and indunas group challenged this view, suggesting that the ongoing costs associated with washing reusable diapers makes the overall expense comparable to disposables, stating *"You can't stop people buying, because they are saying its R4000 – using the Pampers – but using the nappies, it is also the same, and you have to wash every day. You have to buy soap. It's the same. So how can you prevent this?"* This participant seemed to be questioning why women would switch from using disposable diapers, especially when the cost is similar between the two options, yet reusable diapers require more effort to use.

Further, within the young and older men's group, a participant mentioned that the high upfront cost of reusable diapers is a significant deterrent to their use: *"Big shops like Spar or Clicks, or whatever, where they buy Pampers, there is the cloth ones there but they don't want it because it's…expensive."* When asked if women would use reusable diapers if they were provided for free, the elders and indunas group stated that *"Yeah, they would accept it. Yeah, it would be better* [if] *all of us would do that."* However, the younger women pointed out that *"we have them! We do have, but no one is interested in using them,"* and they mentioned that *"we used them before, we also have them at home, but even if I come with it for free and say take them, no one will use."* One of the older women reported using reusable diapers because she did not have money to buy disposables.

Factor 4. Limited water access

Limited access to water was identified as a known issue within the Mnisi area and was mentioned in two focus groups as a factor limiting the use of reusable diapers. In the elders and indunas group, participants simply stated *"they need more water"* to wash reusable diapers. The young and older men expanded this, stating *"we don't have enough water to wash, because you might find that some of the kids have diarrhea, and they have too many babies, and now you remove now the other one, and* [it becomes] *dirty quickly, you are looking for the water and you want to wash the second one and the first one is already full."* Factors that increase the number of diapers used in a household, such as number of babies in diapers and incidence of diarrhea, necessitate more washing and therefore may affect the choice to use disposable diapers. When probed further, all participants confirmed that diarrhea was a common occurrence for infants in the community. Access to water was not mentioned as a concern in the three groups comprised solely of women.

Factor 5. Diaper disposal logistics

While the convenience associated with diaper disposal, as discussed in Factor 1, was a predominant theme across nearly all focus groups, with time savings identified as a key driver,

an interesting and conflicting theme also became apparent. Specifically, participants described the logistical considerations and spatial constraints involved in the actual process of disposing used diapers, noting the significant time and mental energy required.

The most common disposal method discussed was the practice of throwing diapers in the pit toilet or in the yard, followed by burning when it gets full. Participants described the process, stating *"I dig the hole and put it. When it is dry I use the matches to burn", "throwing in the pit toilet. It gets full, but when it gets full, we put in diesel and burn them"*, and *"Digging a pit in the yard, putting the paraffin in and burning"*. This approach requires investment of time and resources, as the holes need to be dug and matches, paraffin, or diesel fuel must be obtained and used. On further discussion about burning, participants revealed the need to *"mix them while they are burning so that they get the fire – or they will only burn the upper ones"*, eliciting that the process takes time and requires monitoring once started.

Another consideration highlighted in the FGDs is that the diapers must be dry to burn, with women sharing strategies such as *"dry them, open all of them, put them on the firewood so that they can dry, so at the evening I collect them all and set them and burn them"* and *"sometimes I put them on top of the roof so they can dry"*. Within the elders and induna group, one participant revealed that it can be a long drawn out process to ensure the diapers are dry enough to be burned, stating *"to dig, 10 minutes. To burn, less than 10 minutes maybe. But to prepare, because you need to burn while they are dry, they got nothing in soak, it can take maybe 2 months to put them in the sun to dry because like in the evening, the dew and what, just fall on top, they become wet again, so it will take like long long long time."*

In contrast, some participants described the disposal process as more straightforward, with one older woman stating *"So Pampers you just put and then you remove and put in the toilet or dig or throw in the grazing camp, that's fine,"* without considering that the hole must still be dug or the time taken to walk to the grazing area, which could be considerable depending on where the house is located within the community. One of the younger women was very descriptive and forthcoming, sharing that she just throws the diapers wherever is convenient: *"most of the time I just throw them like others – I drop them. I throw them anywhere – I'm serious! I want to be honest. During the rain, I just drop them over there in the erosion ditches.*

Some of them are not going with water – now, if the rain start, they wash away. When it rains again you just drop them. There is no need of digging it because the erosion ditches are already there, and if you dig and the plow comes it just digs it back up." This paints the picture of an independent, solitary chore that has been planned out in advance, requires knowledge of the community and must account for weather conditions.

Theme 2: Perceptions of the impacts and health risks associated with disposable diaper pollution on people, animals, and the environment

Throughout the focus group discussions, participants in all groups explored the environmental impacts of disposable diapers, focusing on the pollution associated with their use, including land, water, and air pollution. The conversations centered on the long-lasting effects of disposable diapers on the environment, with participants noting how these diapers persist in the environment for extended periods. One individual in the young and older men group openly expressed this concern, saying, *"They find them. They find the pampers and therefore, even if it is more than 5 years, when they go and dig there they still find them."* The young and older men's group further described how this environmental accumulation contributes to health risks for both humans and animals in the community. They explained, *"Yes, the leftovers, they can take it and then throw it, because Pampers they don't burn the whole thing, there is something that stays, and it's that that can cause problem to us and to the animals."*

The conversation shifted toward a discussion of the direct connection between the disposal of diapers and negative health consequences for people. When the topic turned to burning the diapers, nearly all groups brought up the issue of smoke production, with comments such as, "*there is a lot of smoke when burning, they cough,"* and *"you must cough when you burn,"* and *"cough too much, yes,"* indicating the intensity of the smoke. One of the creche workers mentioned burning them *"around 11 o'clock at night, when they are sleeping you can burn it,"* implying that daytime burning is avoided due to the smoke it generates. Participants expressed concerns about the impact of this smoke on people in the community, sharing that *"it's*

dangerous to someone there that they are sick, they are coughing, lots of things, have wet chest," and perhaps more severely, *"No, I think that smoke is not good to me. When I burn this, someone is gonna die."*

Figure 4.1 *Burning trash at the landfill showing the thick smoke generated*

Participants in all groups also raised concerns about the potential health risks associated with diapers being discarded in waterways, focusing on the consequences of water pollution. A creche worker stated that *"under the river, the animals and even the fish they go under the water and get sick."* One of the older men discussed an explicit One Health aspect, noting that *"The Pampers take long* [to break down]*, even if it is inside the water. And inside the water itself, before we can go to our domestic animals, there is fishes that are living in the water. So the fish eat the pampers, get sick, something comes to eat fish, whether human being or what, get sick from that."* They mentioned scenarios such as, *"The Pampers, they throw it in the river and sometimes we don't have water in our communities, we go there and drink that water,"* and *"So then the water, some of the people in the village, they use that water to wash clothes, and wash themselves with that water. So if it is dirty like that they can get a disease."* Additionally, in the elders and induna group it was mentioned that *"it can be taken by the heavy rain, if the river is full of water, it can transport to another community, and it can cause disease*

to other people, so it's also a challenge sometimes" – once again demonstrating concerns about the negative consequences for people in the Mnisi community and other communities reliant on the same water source. However, as described here, participants only specifically mentioned the potential for negative consequences arising from diapers in the waterways in situations of water scarcity when they are forced to use water directly from the rivers. There was no indication of the frequency of this occurrence. When questioned, younger women in the group expressed skepticism regarding the impact of disposing diapers on the water sourced from the boreholes, stating, *"I don't think so."* Conversely, when asked about its effects on people collecting water for other uses, older women responded, *"no, because they are not drinking it."*

Given the Mnisi community's focus on agriculture, concerns regarding negative health consequences for animals were a significant topic of discussion. Within the elders and induna group, all members stated that they own livestock and have seen cattle and goats consuming diapers, with several groups also mentioning dogs eating the diapers. The younger women stated that *"If you come with your diapers and put them there, when someone comes with the dogs, come and want to see what's there, they will open it and scatter it around, and the land becomes polluted."* Participants acknowledged that animals rely on rivers as a water source, making diaper contamination a big problem. The physical presence of diapers in the water may make it harder for animals to drink – *"Most of the Pampers, they are floating on top of the water. And the cattles want to drink. And they can't drink it because of* [the diapers]*."* The older men discussed that diapers in the water can *"block them, like suffocating,"* and that *"they stop eating and they die."* The elders and indunas pointed out that *"if they eat that Pampers, the digestion inside the animals will be having a problem."* A shared concern amongst the young and older men, and elders and indunas was the impact of environmental accumulation of discarded diapers on grasses, which can affect the grazing abilities of their livestock. They mentioned that *"when the rain rains, their grasses are affected because of that pamper, because it's sort of a plastic, so they don't grow like they are supposed to, it just stops."* Additionally, they expressed, "*It is also affecting our grass, even our trees, because once you dump the Pampers there, it will be very difficult sometimes to have grass or whatsoever because of that Pampers."*

Figure 4.2 *Photo taken in the community showing dogs in areas of trash accumulation*

Theme 3: Barriers and solutions for proper disposal of diapers

In each group, participants shared that this was the first time they had collectively discussed the issue of diaper disposal as a community, with everyone agreeing that it was a significant concern for the community. A creche worker expressed, *"I see the Pampers, all the country is Pampers, that's why I hate Pampers,"* illustrating that the problem is readily visible and widespread within the environment. The community's reluctance to openly discuss the issue of diaper waste was viewed as an obvious barrier to progressing towards solutions. Older women noted, *"No, this is the first time they have talked about it. They don't talk about that, we just complain when we find something on the way. They say it is a problem."* In contrast, the older men, who all reported owning livestock, implied that because they are directly impacted by the problem, they are more inclined to talk about it. They mentioned, *"Yeah but guys like now we talk about it; because it's not easy for them, because they just take them and throw it in the*

bush, so the guys in the morning, they just herd cattle into the grazing areas, they find Pampers, and they haven't seen them, and it is dangerous to our life and to our cattle."

However, men and women in the Mnisi community do not engage in joint discussions on the issues surrounding disposable diapers. There appears to be a tendency to pass judgment on mothers, which may hinder open communication. When questioned about why they believe people discard diapers in rivers or on roads in the community, older women described them as *"reckless"* and that they *"just don't care"*. The elders specifically mentioned that it is the fault of *"the women," and "they just take their child's diapers and throw it on the road."* Despite these challenges, there is a consensus that the first step towards identifying effective solutions for proper diaper disposal should involve the community coming together to *"talk about the diapers as an issue.* There is a feeling of blame towards the external entities that introduced disposable diapers to the community, as within the elders and indunas group, a comment was made that *"when the manufacturing company came and brought them to us, and they never come to us and educate us, to say how to control the situation from the pampers"* and the Induna in the group blatantly stated that *"because you white people you created the diapers."* . Many participants stated that *"there is no option except municipality"* and that *"We won't do anything because we need the municipality to communicate with us, so they can come and collect them, so they know where they can put these things."* However, participants also shared that the municipality does not currently organize general trash collection at all and, even when a skip bin is provided, regular collection is not guaranteed.

Regarding solutions, there is in general a focus on a central collection site amongst the groups, with creche workers saying that there must be *"a specific place to drop the used diapers,"* that *"there is no place to set all the rubbish. No place to put it only"* and *"the only way is to have a bin in our community".* The elders and indunas expanded on this, saying *"if they have got a place where to place their bin, maybe, and then also again to give awareness campaign to the community members that to stop throwing the pampers anywhere, so now we have got a place where we can use to put our pampers there."* However, participants also acknowledge that it will take more than just designating a place or a bin, stating that *"if there is 3 or 4 bins, or even that one, it needs to be a person that will look after that bin, because if the*

bin is full, people are going there and the bin is full and they are just putting next to it." The community understands that there needs to be a system for oversight and management of the waste collection. Interestingly in the group of elders and indunas, they stated that *"If we are not together, as a community member, and take our concern to our head man, I think our head man can show us a place where we can dump our disposal there"* – however, although the Induna was present within this group, no consensus was reached regarding a disposal site.

The other common solution proposed was the return to reusable diapers, with the elders and older women saying, *"the best thing is to bring the napkins, because they were there before, and I don't know where the Pampers are coming from, but they are not good in our life."* A participant in the group of younger women did say that she would be *"willing to try* [reusable diapers] *because they are ruining our community"* and another participant stated that *"maybe if we can come together as a community and agree that we go back to cloth diapers – as some sort of a time, because these things* [disposable diapers] *are becoming so much of a problem."* The elders even went to the extreme of suggesting that disposable diapers be outlawed, saying *"if you can't buy you don't have a choice."*

There was some discussion regarding community involvement in the issue. When the younger women were asked if there was an organization that could help with implementation of solutions, they stated *"Not something that we know of, but if there were something like that, they would take part/support it".* Some participants said they would be willing to help with whatever solutions are proposed, but that they would need to be paid. While most participants said they would not be able to contribute financially towards a solution because they don't have any money – with creche workers saying *"some mothers are struggling, they can't pay"* – some did say they would contribute a small amount, suggesting R20 a week.

Multiple participants shared that there had previously been a group of community members collecting diapers from houses and the rivers and bringing them to a central collection point. Further discussion about this revealed that they were volunteers who had been organized by a community member to come together to start the collection and were hoping the municipality would start to pay them; when they didn't, the collection stopped. Furthermore, it was revealed that the diapers they had collected remained at the central point, with a participant

sharing that *"because that time just when they were collecting, they took the diapers there and put them there and they are still there even today – so what will the municipality do, because since that day they are still there."* It seems that this effort was generally accepted well and valued by the community - when asked about the group, one of the elders stated that *"the group that they were having here. It was good"* and the younger women agreed that it made life easier for them.

Figure 4.3 *Diapers collected by volunteer group piled up at central collection site*

5. Discussion

The aim of this study was to gain an understanding of current drivers behind the use and sanitation practices associated with disposable diapers within the Mnisi community area, and to identify knowledge gaps and challenges experienced by the community in order to establish sustainable solutions. This was accomplished through the facilitation of focus group discussions with distinct groups of community members. Generally, participants conveyed that environmental diaper disposal is a visible issue within the Mnisi communal area, readily discussing challenges and impacts experienced by the community and expressing a desire to come together to work towards solutions. Three key themes were identified based on our analysis which aligned with the objectives of the study.

Objective 1: Describe diaper use and disposal practices, including socio economic and cultural drivers behind decision making, within the Mnisi community

There was general consensus amongst the groups that convenience factors are key considerations in diapering choice, emphasizing that time savings associated with ease of access and use of disposable diapers is essential for the busy lifestyles of today. This is consistent with other studies in which convenience factors were strongly valued by mothers (Jesca & Junior, 2015; Ntekpe et al, 2020; Wambui et al, 2015; Remigios, 2014). However, there was a generational divide in that older participants expressed the belief that rather than busy lifestyles necessitating the use of disposables, the current generation of mothers elect to use them simply because of laziness.

Societal perceptions and beliefs were also discussed as motivating factors in diapering choice, with participants acknowledging a generational divide in diapering preference. Using disposable diapers is seen as more modern and a woman may face judgment from her peers if using reusables. This aligns with other research findings that fashion is a component of diaper choice, with women mentioning they use disposable diapers because everyone else in the

community is, and they can be viewed as a status symbol - if someone of a lower social status is using disposable diapers it becomes prudent to use them as well (Magadza, 2016; Remigios, 2014). Additionally, mothers may face ridicule if their childs' reusable diaper is not perfectly clean, possibly dissuading them from their use. Another societal belief that emerged was the fear that witch doctors could cause harm to children if they obtained the used diapers, although this belief was not shared by all participants.

Regarding cost, there was no consensus on whether it is more expensive to use reusables or disposables. A gender divide became apparent with men expressing the belief that women are not using reusable diapers mainly because of the high upfront cost, but the women contradicted this by stating most have reusable diapers available to them already and do not use them. One woman also stated that even if disposable diapers are more expensive to use, mothers value the convenience factors enough to pay the higher costs. Water access was mentioned by the men as a deterrent for using reusable diapers but was not mentioned by the women, suggesting other factors are more important when choosing to use disposable diapers.

Participants emphasized the value of convenience factors offered by disposable diapers and, while they describe the process and logistics for their disposal, do not seem to acknowledge the significant time and mental energy required as negating some of these convenience factors. Although younger women may be judged as lazy for using disposables, our discussion reveals that they are actually investing a lot of time and energy into disposal as it requires forethought, planning, and time for actual implementation of disposal. Women discuss burning diapers and disposing of diapers in the environment at night in an attempt to hide it from the community. Similarly, in a study conducted in Zimbabwe women discussed dumping diapers in the environment when no one was watching (Remigios, 2014). Aside from a few of the younger men, most men stated that they do not help with disposal as it is a woman's responsibility, making it difficult for them to appreciate the time and energy invested by women into disposal.

Objective 2: Identify knowledge gaps surrounding potential and perceived health risks associated with diaper disposal, in terms of human, animal and environmental impacts

Focus group participants readily discussed the negative effects that disposable diapers can have, demonstrating an explicit understanding of One Health principles when discussing possible impacts on animals, people and the environment. Participants frequently expressed concern for impacts on others in the community and surrounding areas. It was not surprising that negative impacts on livestock were introduced as a major concern given the strong dependence on agriculture in the Mnisi area, as anything that affects productivity will negatively impact the community as a whole and contribute to poverty. However, effects on livestock were only mentioned by the men while women only mentioned dogs eating the diapers.

Concerns about the smoke that arises when burning the diapers are consistent with health impacts mentioned by Jesca & Junior (2015) that sodium polyacrylate dusts cause respiratory irritation and exacerbate respiratory illnesses. Participants recognized that water pollution from diapers could cause negative impacts for people in the local area who are using the river for drinking water, laundry or bathing, and can also affect other communities downstream. However, they were not concerned about general pollution of other waterways, including borehole water, suggesting a knowledge gap around the water cycle. Kordecki et al (2022) discuss that diaper disposal sites near rivers may cause contamination of surface water both locally and downstream, and recommended further research on how diaper waste can affect water quality.

Discussions around impacts from the diapers mostly centered around the physical constituents of the diapers themselves, and while illness and disease were mentioned, negative impacts from the stool contained within the diapers and environmental contamination was not directly acknowledged. Therefore, there may be a knowledge gap regarding mechanisms of disease spread from feces, and consequently hygiene factors associated with child care and diaper disposal. Mothers could be encouraged to put stool into pit toilets before disposing of the diaper, which would reduce fecal contamination in the environment (Ntekpe et al, 2020).

While the Mnisi area directly borders conservation areas and is in close proximity to national parks, participants did not discuss possible effects on wildlife. Kordecki et al (2022) mention that diaper sites generally were not located in close proximity to conservation areas but that

many rivers terminate within conservation areas. There is an opportunity to educate on how diaper waste may affect wildlife within these conservation areas, and linking diaper waste to health of conservation areas may stimulate government engagement due to revenue from tourism that is generated from these areas.

Objective 3: Identify potential community-led solutions to the problem of environmental pollution of disposable diapers

Littering of disposable diapers is an issue that community members experience and acknowledge on an individual basis but that the community does not discuss - participants stated that this was the first time they were conversing on these issues as a group, although there is a desire to motivate change and be part of solutions. While the older men who own livestock come together regularly such as when grazing the animals or at the dip tank, there are no inherent social opportunities for men and women to do the same. Therefore, a first step in moving towards solutions will be initiating opportunities for community discourse. Judgment between genders and generations around how mothers use and dispose of diapers is a key barrier to working towards solutions as it will hinder collaboration, and there is a need to encourage knowledge sharing, support and understanding. Participants expressed that young women simply don't care that improper disposal of the diapers affects the environment and the community. However, this sentiment was directly challenged by the comments made by current mothers revealing that they do care how these actions affect the community, but they have no other options, and largely carry this mental burden on their own. Magadza (2016) found that over 50% of people report trusting other parents, while only 7% reported trust in local authority figures, so support systems involving community members would be beneficial.

Participants expressed feelings of lack of agency, laying blame on the manufacturing companies for introducing disposable diapers and stating that the municipality is the only entity that can solve these problems. At the same time, the community acknowledges that disposable diapers are now ubiquitous within the community, and that the municipality has been unsuccessful in providing solutions. While there have been initiatives within the community

such as the self-organized volunteer program for diaper collection, ultimately this was not sustained because the program was not acknowledged by the municipality and participants had hoped to be paid for their efforts. Engaging local leadership in solutions will be essential for increasing feelings of agency - while the local induna was present for the focus group, he seemed to insist on the manufacturers taking responsibility, rather than taking initiative in solutions. Governments are overwhelmingly underfunded with regards to sanitation programs, while manufacturing companies continue to benefit financially from disposable diapers. There should be continued efforts to petition for companies to take responsibility in acknowledging the LCA of disposable diaper production and use and to continue investment and research towards a more circular economy through offering eco-friendly, biodegradable options.

Participants proposed establishment of a central collection site for used diapers to be deposited, but also acknowledged that in order for this to be a viable solution, there must be regular collection and maintenance of the site. This is consistent with Jesca & Junior (2015) in which study participants cited the ultimate solution would be to have local government authorities provide bins which are regularly emptied. When reviewing points already brought up by participants regarding diapers in the environment, there are many factors to consider for this to be successful: the site must be inaccessible to animals and children, diaper accumulation may attract rodents which could carry disease (Berrian et al, 2016), there needs to be consideration for how far users are willing to travel for disposal and therefore multiple sites may be needed within a community, and there must ultimately be a plan for where the diapers will be taken as chemicals and pathogens will continue to leach into the environment. Superstitious beliefs about witchcraft as discussed previously may discourage some community members from using a central collection site. Designating a central collection site allows for people eventually tasked with clearing it to use appropriate personal protective equipment (PPE) - when collecting diapers scattered in the environment, there is a higher risk of being exposed to fecal matter and contaminants.

Participants also discussed a transition back to reusable diapers, with some recommending a complete ban on disposables. However, due to gendered differences in care, this could negatively impact women, which is discussed by Perez et al (2020) in which they discuss that

the amount of time spent on house care activities such as childcare can have a negative effect on employment opportunities and mental health. It is not realistic to expect a complete transition to using reusable diapers, especially when considering that in developed countries reusable diapers make up less than 2% of the market (Magadza, 2016). However, it may be feasible to work towards reducing the overall reliance on disposables, encouraging the use of reusable diapers when weather is favourable and reserving disposables for when washing is not possible for various reasons. Although studies on environmental impacts of reusable diapers as compared to disposable diapers can be conflicting, in the Mnisi area where washing is done by hand and diapers are dried in the sun, energy inputs are certainly less. Diapering choices are not only an individual decision but social pressures factor in as well - fear of judgment may discourage women who may be interested in using reusable diapers from doing so, and there must be a shared community initiative to make this change. Older women in the community have vast amounts of experience with reusable diapers and should be encouraged to share their knowledge and support with younger mothers, and if an initiative to move back to reusable diapers is started, there should be regular and ongoing opportunities for mothers to convene and discuss difficulties, troubleshooting and lessons learned.

Just like disposables, reusable diapers have changed and improved significantly over the years and consumers now have access to a wide variety of types - Aishwarya & Priyanka (2020) discuss all-in-ones, shaped nappies, prefolds and pocket nappies, all of which offer different functionality and convenience factors. These reusables can be attractive and stylish and offer improved functionality and convenience. In some areas, collection and laundering services may also be available which take this workload off mothers. If similar services and increased variety of reusable diapers were available in the Mnisi area, mothers may be more willing to use them.

Limitations and future recommendations

Some limitations of the study included small sample sizes for most of the focus groups, which could be addressed in the future by offering focus groups at different times of the day and/or different locations within the community. In the focus group where the induna was present, participants may not have felt as free to express their opinions regarding current

logistics behind availability of waste services. Results of this study are likely only applicable to these communities, but similar studies could be done in other areas in South Africa. Similar studies could also be used which focus on other absorbable hygiene products which can be disposed of in the environment such as sanitary pads.

Final remarks

This study accomplished the aim of engaging the community to gain a deep understanding of current diapering practices and issues encountered by community members as well as identifying possible interventions which can be implemented in the community. Findings of this study reveal that motivations behind diapering choices are multifactorial with many variables to be considered when implementing sustainable solutions. While participants understand that there are health impacts and risks associated with littering of diapers, this seems to be outweighed by the convenience factors. Interventions should provide similar or improved convenience factors to be accepted by mothers and integrated into daily life. Social norms and pressures were shown to heavily influence decision making around diapering choices, denoting that interventions should be targeted on a community - rather than individual - basis, as interventions will be most successful if accepted by the community as a whole. Women especially should be empowered to have their voices heard when working towards solutions and supported to make informed choices. Further research and educational campaigns focusing on the association between environmental diaper disposal and water pollution, pathogen spread and livestock health should be implemented.

Results from the focus groups will be presented back to the communities and should be taken as a first step in engaging community members and leadership. Focus group participants expressed concern for how their diaper disposal choices affect their families, communities, and surrounding areas, which can be capitalized on to motivate change. There is ultimately not going to be one blanket solution, but rather communities should focus on a combination of interventions including reducing reliance on disposable diapers and engaging leadership and key stakeholders to provide safer options for their collection and disposal. Ultimately the community will need to acknowledge their part and take responsibility for solutions.

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Appendix A: Framework for focus group discussions

Focus Group Discussions – One Health Approach, Disposable nappies

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Note for facilitators: Mention that we are recording the meeting and will be taking pictures

We will use Participatory Mapping as a tool to stimulate discussions and improve our understanding of local contexts.

Materials

- Flip chart papers
- Coloured pens
- Coloured paper and scissors
- Coloured bottle caps
- String different coloured wool (e.g. to represent a river)
- glue
- Different coloured stones, leaves, or similar items that participants can collect themselves if there is enough time.

Venue It was agreed that it would be useful to hold the Focus Group Discussions (FDGs) in an attractive area where dumping of disposable nappies is occurring.

Need a large enough space for group participants to ensure that everyone can easily reach materials. Some people work on the ground but tables often preferable.

Facilitator Guide conversation to get what you want out of it but with as little input as possible to let the group relate their stories and ideas. Ideally one facilitator per group but can rotate amongst groups.

Recorder To record the points during discussions; preferably one recorder per group
Size of groups – divide into about 8-10 per group

Technique

After introducing ourselves, ask - Do you perceive disposable diapers littering in the local area as a problem? Why?

- Facilitator to introduce the session explaining purpose and approach.
  - Previous exploratory studies undertaken in the area indicated that community members identified littering of disposable diapers in the environment as a problem
- Emphasize that its important to obtain local perceptions of challenges around waste as global problem with local impacts (or something to this effect); emphasize they are not the only ones facing these challenges. The purpose of these initial focus groups is to

gather more information about the current situation – we DON'T have the answers or the solutions, but in order to do so we need to learn more about how diapers are currently used and disposed of, and what the community understanding is of what problems this causes.

- Questions or comments from group.
- Explain going to ask the group(s) to create a visual picture or map of the area, showing sites where disposable nappies are typically thrown away.
    - We are hoping that you can help us understand your community and where some of the issues are
- Keep it fun and engaging 😊 – invite the group to teach you about their situation; local experts

Mapping

- Draw (or add) a feature of the area on a piece of flipchart paper (e.g. blue wool strands for a river or brown for a road – don't stick it down at this stage, let the group do that once they have decided on the place). Then ask the group to fill in houses, schools, the clinic, roads or other features using coloured paper, drawings, leaves (e.g for forests). At first, you may need to encourage them by asking questions, e.g. can you show me where the clinic is? But then let them do it – the idea is for the group to discuss and rearrange and generate ideas. The less input from the facilitator the better.
- Encourage the group to use visual symbols – coloured papers to represent different things on the map, depending on time, they can use leaves, stones, that they collect their own materials.
- Then ask them to point out areas where nappies tend to get thrown out more frequently, e.g. using stones to display on the map, the number of stones showing the extent of the problem. Once agreement is reached on the different sites, can use paper or pens to mark permanently. If there are not a lot of nappies in a particular area where they are usually disposed (e.g. washed away by rain), prompt them to show where they are normally disposed if they haven't identified the area.
    - Can add more pieces of paper for sites with lots of diapers accumulating
- If there are fewer nappies than usual, ask what might have happened to them (washed away, stray dogs, etc.).
    - Are there seasons or times of year where there are more or less diapers?

Questions

1. Age and employment statusjj
2. Do they take care of children or grandchildren?
    a. If yes – are any of them in diapers?
    b. If yes – do you use disposable or reusable?

    Why do you think people throw nappies away near… (rivers, forests, whatever) – this may get you to the 'who' without directly asking.

4. Who is putting them there?

5. Are there any other ways that people dispose of nappies? For example, burning or burying them? Can you add areas where this happens to the map as well.

6. Do you think there are risks associated with littering of diapers in rivers/streams/bush?

7. Do you think there are risks associated with burning of waste?

    a. On the environment?
    b. And people?
    c. Animals?

If the question is not immediately understood, ask questions such as:
Where do you collect water? Do you think littering of the diapers has any effect on the borehole water? Where do you think the water from the borehole comes from?
If nappies are burnt, how does it affect the air we breathe?
Are all the parts of the nappies burnt or are some left behind?
Are animals ever affected by people throwing nappies in 'natural areas' 'ehlatini' (use local term), or through them being burnt? What about children?

What do you think happens to the diapers that are thrown in the stream? And the diapers that are buried?

8. Do you think there are any negative effects on your community? What about other communities (ie downstream of river)?

What about in 20 years when your children are having their own children?

Does the environment look different in your community than it did when you were a child?

9. Who should clean up the diapers in the bush/river/stream?
   Have there been efforts to clean up disposable nappies in your area yet?
   - What happened? Did it work? Why, or why not?
   - What worked? Even if something failed, there might be aspects that worked?
   - What were the challenges? For example, distances people can walk to dispose of nappies; storage areas; collections from the central point; etc.
   - Who was involved?
   - Can you think of any ways to engage the municipality in helping come up with a solution for the problem? Have there been other problems/situations in the community that have been solved in this way?

10. What challenges are experienced in terms of collections of disposable nappies and other waste?

11. How do the clinics and creche dispose of nappies?

12. If no outside support were available, what could the community do to avoid nappies being dumped in the 'veld', 'environment', 'ehlatini'? Who would need to be involved and what types of resources would be needed?

13. The surveys indicated that the majority of people use disposable diapers. Would reusable/washable diapers be utilized by community members? Why or why not?

    a. Would mothers feel embarrassed to use reusable diapers?

Post-FDG Follow up

Engage with clinics, Dept of Health, Agriculture, Dept Water and Sanitation, municipality, disposable diaper manufacturers etc.
Composting – experiences of other projects, etc.
Follow up workshop - to be refined, based on the ideas of these FDGs.

- Report back on the surveys and FDGs
- What can the community do to address this issue? Is anyone already doing this? Is anyone supporting you? If no-one has started, is there anyone who would be willing to lead this? Who?
- In the interviews, a lot of people said they would be willing to take the nappies to a central place for disposal. Is there a specific place or places in your community that would work as good collection points/places for collection? Could you add them to the map. Would people be willing and able to drop them at these collection points?
- What are the advantages of a central collection point? (prompts risks to animals, human and children's health etc.).
- If there is no outside support to deal with the issue, what type of things can the community do to address the disposal of nappies in the environment?
- Will you be willing to contribute to an initiative to address the nappy problem? What assets are available to address the issue (human, material, physical financial natural etc.). ABCD approach.

Appendix B: Ethics Approval, Faculty of Humanities

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Humanities 100
Since 1919

31 March 2023

Dear Dr A Lowe

Project Title:	Community Based Interventions and Perception of Health Risks Associated with Disposable Diaper use in two rural communities in South Africa
Researcher:	Dr A Lowe
Supervisor(s):	Dr I Van Wyk
Department:	Veterinary Tropical Diseases
Reference number:	96042878 (HUM006/0122)
Degree:	Masters

I have pleasure in informing you that the above application was **approved** by the Research Ethics Committee on 31 March 2023. Please note that before research can commence all other approvals must have been received.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. Should the actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely,

Prof Karen Harris
Chair: Research Ethics Committee
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: tracey.andrew@up.ac.za

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Appendix C: Ethics Approval, Faculty of Health Sciences

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.
- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IORG #: IORG0001762 OMB No. 0990-0279 Approved for use through February 28, 2022 and Expires: 03/04/2023.

Faculty of Health Sciences **Research Ethics Committee**

22 March 2022

Endorsement Notice

Dear Dr A Lowe

Ethics Reference No: REC154-20
Title: Community Based Interventions and Perception of Health Risks Associated with Disposable Diaper use in two rural communities in South Africa

The **New Application** as supported by documents received between 2022-01-14 and 2022-03-16 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2022-03-16 as resolved by its quorate meeting.

Please note the following about your ethics approval:
- Ethics Approval is valid for 1 year and needs to be renewed annually by 2023-03-22.
- Please remember to use your protocol number (REC154-20) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:
- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

On behalf of the FHS REC, Professor Werdie (CW) Van Staden
MBChB, MMed(Psych), MD, FCPsych(SA), FTCL, UPLM
***Chairperson**: Faculty of Health Sciences Research Ethics Committee*

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health).

Research Ethics Committee
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