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EAAA conceptualized the study and participated in data collection. HMYA contributed to the design and conduct of the experiments. EAAA and HMYA contributed in writing the manuscript. All authors read and approved the final version of the manuscript.

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Bacterial Contamination of Children's Toys in Some Houses in Sana'a City, Yemen

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Abstract:

Bacteria can invade from outdoors and infect toys for kids. Children might become infected by contaminated toys and are at the risk of contracting an illness. The study aims to isolate and identify bacteria found on the surfaces of children's toys, to determine antibacterial susceptibility against various disinfectants, and to evaluate hygiene knowledge of mothers. A total of 30 children's toys samples were collected and subjected to microbiological examination. The results showed that 20 of 30 toys samples were positive for bacterial growth. Most bacteria found in children's toys were *Staphylococcus aureus* and *Bacillus sp*. The results of antibacterial susceptibility showed that Chlorex had the strongest effect on isolated bacteria, followed by disinfectants which were Dettol and Dikitol. While Fourtol had no effect on these bacteria. Almost every kind of toy sample was contaminated with bacteria. Mothers need to be more conscious of the fact that their understanding of how to clean toys is inadequate. This study recommended that children should be taught proper hygiene practices, that toys should be managed by closing them after use, and cleaning according to their kind.

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INTRODUCTION

Children ages 1–5 years (pre-school) are ready for school, and in order for them to learn well, their senses, receptor system for stimulus, and memory process must be ready. Playing is the method of learning throughout this period (Damanhuri *et al*., 2024). Pre-schoolers essentially spend the majority of their time engaging in games. Children play with toys that are specifically designed for them, such as dolls, balls, toys for cooking, crafts, doctors, and cars, among other things (Dag *et al*., 2021). Additionally, toys have a direct impact on children's health. The spread of disease pathogens through this media might be the cause. The World Health Organisation found that environmental factors were linked to illnesses including diarrhoea in children aged 0–14 years (Martinez--Bastidas *et al*., 2014). Diarrhea claims almost 500,000 lives yearly in children under the age of 5 years. In addition to the high number of deaths and the effects of diarrhea in children that survive, many of these children still have recurrent diarrhea. Several studies globally have shown that diarrhea-causing organisms are prevalent on fomites. Young children share their toys, play on dirty floors and put items in their mouths which all could contribute to the transmission of diarrhea-causing pathogens (Ledwaba *et al*., 2019).

Soft toys examined from DCCs, homes, and waiting areas were shown to have greater levels of bacterial contamination than nonporous toys (Merriman *et al.*, 2002; Biranjia-Hurdoyal and Quirin, 2012). Children's toys in the households were contaminated with *Bacillus sp, Klebsiella sp, Staphylococcus aureus, and Enterobacter bacteria* (Putri *et al*., 2018). Aleksejeva et al. (2021) reported that *Bacillus sp, Staphylococcus arueus, Streptococcus sp* and coliforms were found on different toys in households. The contribution of children's toys from Sana'a city households to the spread of organisms that cause diarrhoea in children younger than five years old has not been studied. This study was therefore aimed to isolate and identify contaminated bacteria from children's toys in houses, determine antibacterial susceptibility for isolated bacteria against various disinfectants and determine the awareness level of mothers in cleaning toys.

MATERIALS AND METHODS

Study area and design

This cross-sectional study was conducted at some houses found in some neighborhoods in Sana'a city including, Asr neighborhood, Shaoub neighborhood, Beit Boss neighborhood, Haddah neighborhood and Tahrir neighborhood, which was located in Yemen.

Sample collection

A total of 30 samples of children's toys were collected from eight different homes in clean thermal bags, labelled and transported to the laboratory. The samples were cultured on the same day it was collected.

Isolation and Identification of bacteria

The samples taken from the toys were cultured in (Nutrient Agar Medium) by taking a swab of waste from toy surface and spreading it on the plate. It was incubated at 37 °C for 24 hours in an inverted position. After incubation, the colonies that were similar in morphological characteristics in one dish were observed (Saleem *et al.,* 2018; Ebah *et al*., 2024). One colony was taken from bacterial culture for purification and identification by morphology and biochemical characters using standard biochemical tests as reported in previous studies (Bergey and Holt, 2000; Saleem *et al.,* 2020; Aernan *et al*., 2023).

Antibacterial susceptibility testing against various sterilizers

The disk diffusion method was used to carry out the sterilizer effectiveness testing. The test microorganism was seeded on Mueller Agar Media using the spread plate method (Iqbal *et al.*, 2016). Filter paper was used to make discs

and then dipped them in the required sterilizer, the sterilizers used in this study include Dettol (Chloroxlenol, Manufactured by Reckitt Benckiser, British), Clorox (sodium hypochlorite, Manufactured by United cleaning products manufacturing, Yemen), Dikikol (phenol, Manufactured by Yemeni Company for Soap and Detergent Industry Ltd., Yemen), Fourtol (alcohol, Manufactured by four clean lab, Yemen). A sterile forceps was used to place the discs immersed in sterilizer on the surface of the medium. The set up was incubated aerobically at 37°C for 24 hours. The sizes of the zones were noted and the most effective sterilizer was recorded (Beier *et al*., 2016; Iqbal *et al.,* 2015).

RESULTS AND DISCUSSION

Types of study samples

Table (1) showed types of children's toys in this study. It is apparent that out of 30 toys 7(20%) were plastic, 8(30%) cloth, 7(20%) rubber, and 8(30%) wooden toys from children aged (1-5) years.

Table 1. Types of children's toys in this study.

Toys material	Number	%age
Plastic toys	7	20%
Cloth toys	8	30%
Rubber toys	7	20%
Wooden toys	8	30%
Total	30	100%

Incidence of bacteria in children's toys

Table (2) showed that out of a total of 30 toys, 20 toys (66.66%) had bacterial growth, while 10 toys (33.33%) didn't show bacterial growth. Nearly similar results were recorded with Hohashi et al. (2005) who found that, 250 out of 274 objects (91.2%) of the toys were contaminated with bacteria. Putri et al. (2018) reported that 38 out of 40 toys were contaminated with gram-positive and gram-negative bacteria, and Aleksejeva et al. (2021) found that 101 out of 120 samples showed positive for bacterial growth. In contrast to our results, another study conducted by McKay and Gillespie (2000) reported that all samples showed positive result for bacterial growth, and Merriman et al. (2002) found that all samples showing moderate to heavy bacterial contamination.

Table 2. The incidence of bacteria in children's toys.

Bacterial growth	Toys samples	%age
Positive	20	67%
Negative	10	33%
Total	30	100%

The large number of positive cultures may be explained by children's propensity to put their fingers in their mouths and noses and by laxer adherence to sanitary practices, particularly with regard to hand cleanliness. The likelihood of germs, particularly those found on toys, spreading is increased by several circumstances. Furthermore, when kids play with toys without washing their hands after eating or using the restroom, food particles and biological material from patients can contaminate the environment, including toy surfaces, giving microorganisms nutrients and enhancing their ability to survive in the environment (Randle *et al*., 2013; Hashi *et al*., 2017). However, there was a low incidence of toy cleaning in households. One reason for this is thought to be that, because only a limited number of children use the toys, less need is felt to perform cleaning. In addition, the common methods of cleaning at homes involved wiping or washing with water and ordinary soap, and no disinfectant was utilized at all (Inui and Takizawa, 2000).

Identified bacteria isolates

Table (3) showed that identified bacteria isolates were gram positive in all children toys samples. 16 (69.6%) isolates from *Staphylococcus aureus* were observed in 11 toys, while 7 (30.4%) isolates from *Bacillus* sp. was found in 9 toys.

Our results agree with other studies, Avila-Aguero et al. (2004), Putri et al. (2018) and Aleksejeva et al. (2021) who reported that the most bacteria found in toys samples was *S. aureus* and *Bacillus* sp. This compatibility in results might be due to that *S. aureus* is normal flora in the skin, mouth, and respiratory system, while *Bacillus* sp. is found largely in the soil. It is possible for dust particles to be present on toys and become contaminated with *Bacillus* sp.

Table 3. Identified bacteria isolates from children toys.

Bacterial species	No of positive toys samples	No of bacterial isolates	% age
Staphylococcus aureus	11	16	69.6%
Bacillus sp.	9	7	30.4%
Total	20	23	100%

Percentage of bacterial contamination according to material of toys samples

Percentage of bacterial contamination were more in rubber toys compared to other toys, followed by cloth toys, plastic toys, and wooden toys, respectively (Figure 1).

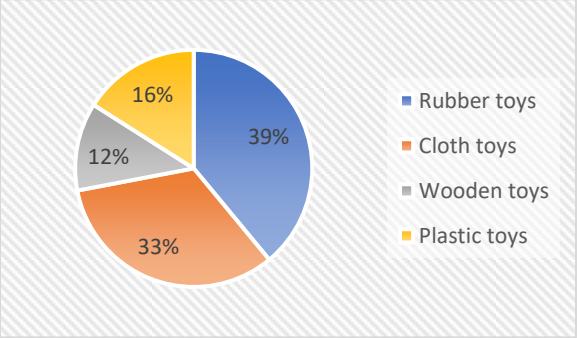

Fig. 1. Percentage of bacterial contamination according to material of toys samples.

Antibacterial susceptibility against various sterilizers

Table (4) appears that isolated bacteria from children's toys showed high rate of sensitive to Chlorex as sterilizer, which had the strongest effect, followed by disinfectants which were Dettol and Dikitol, while Fourtol had no effect on these bacteria. In contrast to our results, Parnia et al. (2009) noticed that all the disinfectants used in the study were evaluated have high disinfecting potentials, Ibfelt et al. (2015) showed that disinfectants used in study show very few pathogenic bacteria were found in the toys, the intervention reduced the presence of bacteria. Jiang et al. (2018) reported that disinfectants were the most effective for reducing bacteria *Bacillus* sp., and Beier et al. (2021) found that ammonium chloride was the most effective disinfectant against *S. aureus*.

Table 4. Types of children's toys in this study.

Type of product	Name of product	Effect	
		effect	No effect
Sterilizer	Clorox	+	-
Disinfectants	Dettol	+	-
	Dikitol	+	-
	Fourtol	-	+

(+) clear zone, (-) no clear zone

Management of toys by mothers

As indicated in Table (5), the frequency of toy cleaning in a given month was contingent upon the necessity. When the toys were unclean, mothers cleaned them 7 (87.5%). All mothers used cloths or washed the toys 8(100%) to clean them. Toys are first divided by mothers according to their cleaning methods, then they are cleaned with clean water and wiped with clean towel 8(100%). This finding can be explained by the low rate of toy cleaning in households, which is believed to be caused by the fact that fewer children use the toys, which reduces the need for cleaning. Additionally, toys

at households are often cleaned by wiping or washing with water and regular soap 8(100%) without using any kind of disinfectant (Inui and Takizawa, 2000).

Table 5. Management of toys by mothers.

Mothers Practice	Number of Mothers	%
Clean Toys	8	100%
Toys cleaning in a month:		
1) Once	1	12.5%
2) Twice	0	0%
3) Three times	0	0%
4) depend on needs, cleaned if necessary	7	87.5%
Cleaning ways:		
1) Wipe cloth	8	100%
2) Wash	8	100%
Cleaning materials:		
1) Water	0	0%
2) Water and soap	8	100%
3) Special cleaning solutions	0	0%

Knowledge of mothers about hygiene in house

Table 6 demonstrated that the majority of mothers (100%) have sufficient knowledge about cleanliness. Their knowledge was also passed on to the kids. Mothers wash their children's hands with soap and water 8(100%), and do not use antiseptic hand soap 0(0%). Mothers have good knowledge for washing their children's hands before and after eating 8(100%). The percentage of mothers who wash their children's hands after urinating and defecating was 4(50%). Mothers' knowledge on washes their children's hands after holding toys are good but no implementation 0(0%). This could be due to the fact that socio-economic status is one of the most important social determinants of health and disease (Pradhan and Sobt, 2024).

Table 6. Knowledge of mothers about hygiene in house.

Mothers Hygiene Knowledge	Number of mothers	%
Hand washing knowledge	8	100%
Hand washing materials:		
1) water and hand soap	8	100%
2) water and antiseptic hand soap	0	0%
Wash hand before eating	8	100%
Wash hand after eating	8	100%
Wash hand after urinating and defecating	4	50%
Wash hand after holding toys	0	0%

CONCLUSION

This study showed that children toys can shelter bacteria with a high microbial load. Although most bacteria isolated from children's toys were *Staphylococcus aureus* and *Bacillus* sp., they have the potential to cause infections in children. Toys can also serve as stores and carriers of bacteria, which are transmissible from person to person. The isolated bacteria showed antibacterial susceptibility against disinfectants and soap. Mothers need to be conscious of the fact that their understanding of cleaning toys is inadequate. Maintaining a high standard of personal cleanliness and environmental

sanitation among children is crucial in order to stop the spread of illnesses.

DECLARATION

Ethics approval

The study received ethical approval from the Department of Biological Sciences, Faculty of Science, Sana'a University, and it was registered at the University of Sana'a. Additionally, every parent who serves as the primary carer in each home has given their approval.

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CONFLICT OF INTEREST

There is no conflict of interest among the authors regarding this publication.

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