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Full Length Article

Can Shopping Carts Act as Potential Source of Drug-Resistant Enteric Bacteria?

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Abstract

Despite the notable increase of shopping centers and supermarkets in Oman during the last recent years, along with the increasing number of reported incidents of inflammation of the stomach and intestines (gastroenteritis), our knowledge about the microbiology of shopping carts in this region and their role as source for transmission of enteric bacteria is still scarce. So, this study was done to examine the bacterial contamination of shopping carts with special emphasis on enteric bacteria in A'Sharqiyah region, Oman. One hundred forty different shopping carts surfaces were sampled randomly from 14 shopping stores located in A'Sharqiyah region, Oman, during the period from November 2018 to August 2019. Samples were cultured to determine heterotrophic plate count. Pure isolates were then obtained and characterized biochemically. The isolates were finally tested for antibiotic resistance. The heterotrophic plate count per shopping cart was found to fall between 3.3×10^2 and 2.2×10^6 CFU/cm2 surface area. The detected bacteria belonged to 16 bacterial species (7 enteric bacteria and 9 non-enteric bacteria). All tested enteric bacteria showed resistance against at least 4 antibiotics. Shopping carts were found to contain varying levels of heterotrophic bacteria which included drug-resistant enteric bacteria. These variations are more likely due to the low hygienic level, the type of food items placed in the tested shopping carts, the frequency of use and the growth conditions. Data indicates that shopping carts may act as source for drug-resistant enteric bacteria and may act as a medium for transmitting heterotrophic bacteria between shoppers.

Keywords: Shopping carts; Drug-resistant; Enteric bacteria; Oman

Introduction

The original design of shopping carts was invented and patented by Sylvan Goldman in 1940. 1 He was the owner of Piggly Wiggly supermarket chain in Memphis, Tennessee, USA. The design was then improved upon by Orla Watson and patented in 1949 (Catherine 2006). Later, shopping carts became popular in supermarkets and groceries and many developments and new designs were introduced to cater the needs of the customers.

Despite the specular and clean appearance of supermarkets and shopping centers, there might be undesirable microorganisms on the handles and bases of the shopping carts (Gerba and Maxwell 2012). Indeed, latest investigations have demonstrated that shopping carts are considered to be as one of the most

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contaminated communal surfaces, and an emerging common source for foodborne pathogen infection for infants (Fullerton *et al*. 2007; Irshaid *et al*. 2014). Surprisingly, Reynolds *et al*. (2005) determined the mean of heterotrophic bacterial plate count on shopping carts may range between 5 to 41.5 per cm^2 (Reynolds *et al*. 2005). The bacterial contamination of shopping carts may possibly happen from direct contact with raw food materials or by previous users (Blanco *et al*. 2003; Carrascosa *et al*. 2019).

The detected bacterial species on shopping carts vary and may include enteric bacteria and non-enteric bacteria (Irshaid *et al.* 2014; Carrascosa *et al.* 2019); some can be drug-resistant (Irshaid *et al.* 2014). Previous studies showed that enteric bacteria and *E. coli* seem to exist in numbers on cart handles higher than other surfaces with which shoppers may touch like ATM screens and buttons, eating place's tabletops, and elevators (Gerba and Maxwell 2012). Based on previous studies, shopping carts can be described as in-animate objects involved passively in transmission of pathogenic bacteria (fomites).

In Oman, despite the notable increase and expansion of shopping centers and supermarkets during recent years, along with the increasing number of reported incidents of inflammation of the stomach and intestines (gastroenteritis), no published data deals with the bacterial contamination of shopping carts that may expose customers for many diseases. In view of the above, this study was done to examine the heterotrophic plate count bacteria on shopping carts. The study aims also to determine if any enteric bacteria are present, and if present, are they virulent? The findings of this research will enhance public awareness regarding shopping baskets and carts contamination through health education and promotion and conducting specialized public awareness sessions to improve public health education and promotion in the Sultanate of Oman in general and at A'Sharqiyah region in particular.

Materials and Methods

Study region and samples collection

The study was conducted in A'Sharqiyah (the eastern region of the Sultanate of Oman). The samples were collected from different supermarkets distributed along the region. The samples were collected from November 2018 to August 2019. A total of 140 shopping carts surfaces were sampled to determine heterotrophic plate count. The shopping carts in the selected supermarkets were sampled using a sterile cotton swab immersed in sterile normal saline solution. The swabs were rolled on an already measured surface of each shopping cart.

Determining the heterotrophic plate count and isolation

plate count was determined using nutrient agar (NA) plates after dilution. Plates were incubated at 37°C for 48 h. In order to isolate bacteria, separated colonies that differ in colonial morphology were transferred into new NA plates to obtain pure culture as described before (Jacob *et al.* 2016). The isolated bacteria were further cultivated on a series of selective media including McConky agar, Simmons citrate agar, and eosin methylene as differential media to have a first clue about their identity. Stocks of pure bacterial cultures were cultivated on NA slant media and store at 4°C for further analyses. Another stock cultures containing glycerol (30%) were used for long-term storage and kept at -20°C (Jacob and Irshaid 2015).

Identification of contaminating bacteria

The first clue about the identity of bacterial isolates (in pure cultures) was obtained by their growth on selective media as mentioned earlier. The isolates were further characterized by Gram stain and biochemical analysis based on Bergey's Manual of Systematic Bacteriology. Enterobacteriaceae members were confirmed by the analytical profile index (API) 20E system (bioMérieux, France) which includes a biochemical panel for identification and differentiation of members of the family Enterobacteriaceae. Control bacterial species available from ATCC were included as quality control.

Antimicrobial resistance

The *Enterobacteriaceae* isolates were examined to determine their antimicrobial resistance by the agar diffusion method. A variety of antibiotics was used including ampicillin, cefixime, ciprofloxacin, cloxacillin, cotrimoxazole, erythromycin, gentamicin, nalidixic acid and tetracycline. The zones of inhibition around the antibiotic discs were measured in millimeters. The zones of inhibition were compared to the resistance cutoff point suggested by the NCCLS (2000).

Results

Evaluating the bacterial contamination

The average numbers of heterotrophic bacteria, counted as heterotrophic plate count from the shopping carts in the studied shopping centers, are shown in Fig. 1. The average number among all selected stores was $6.58\times10^5 \pm 1.48\times10^6$. The lowest number of bacteria was observed on shopping carts from store 11 (1.3×10^3) whereas the highest number (4.2×10^6) was detected on carts from store 7. The lowest number of bacteria on cart surfaces was found only in store number 11, followed by stores 4, 9, 13 and 14. In contrary, the highest number of bacteria on shopping carts surfaces was found in stores 1 and 7 followed by stores 3, 6, 10, 12, 2, 5 and 8.

Identification and abundance of contaminating bacteria

A sum of 207 bacterial species was obtained from the

Table 1: Frequency of Enteric bacteria and Non-enteric bacteria isolated from stores shopping carts used at A'Sharqiyah (the eastern region of the Sultanate of Oman)

Store	Detected bacterial species	
	Non-enteric bacteria	Enteric bacteria
Store 1	*Bacillus* sp., *B. pumilus*	*Escherichia coli, Shigella sonnei, Klebsiella pneumoniae*
Store 2	*B. thuringiensi, Burkholderia cepacia*	*K. pneumonia,*
Store 3	*Staphylococcus haemolyticus, Acinetobacter calcoaceticus*	*K. oxytoca, Yersinia enterocolitica*
Store 4	*S. epidermidis*	*K. oxytoca, Y. enterocolitica*
Store 5	*S. saprophiticus*	*E. coli, S. sonnei*
Store 6	*Bacillus* sp.	*E. coli, K. pneumonia, Y. enterocolitica*
Store 7	*S. saprophiticus*	*K. pneumonia, Y. enterocolitica*
Store 8	*B. thuringiensis*	*E. coli*
Store 9	*S. epidermidis, A. calcoaceticus*	None
Store 10	*B. cereus, S. haemolyticus*	*E. coli, S. sonnei, Y. enterocolitica*
Store 11	*B. pumilus, B. cepacia*	*Y. enterocolitica*
Store 12	*S. epidermidis, B. cepaci, A. calcoaceticus*	*Enterobacter cloacae, K. oxytoca*
Store 13	*S. haemolyticus*	*E. coli, S. sonnei*
Store 14	*B. thuringiensis*	*S. sonnei, E. cloacae, K. oxytoca*

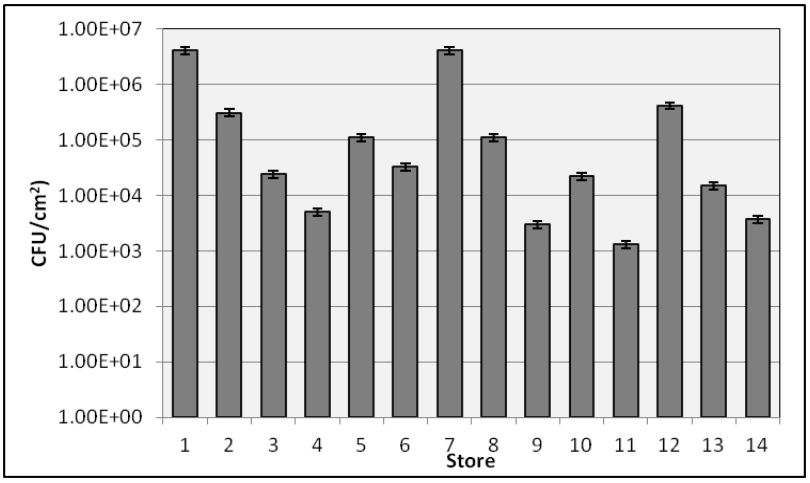

Fig. 1: The heterotrophic plate count (CFU/cm^2) on shopping carts (n = 10) used in 14 different stores at A'Sharqiyah (the eastern region of the Sultanate of Oman)

selected shopping carts. The detected species and their percentages are shown in Fig. 2. The most frequently isolated bacterial genus was *Bacillus*; where 40 isolates were obtained constituting 19.3%, followed by *Staphylococcus saprophyticus*, where 34 isolates were obtained constituting 16.4% isolates, and the lowest was *Klebsiella pneumoniae* with 3 isolates (1.4%). The identified bacterial isolates were also categorized into enteric bacteria and non-enteric bacteria (7 enteric bacteria and 9 non-enteric species). Enteric bacteria include: *E. coli*, *K. pneumonia*, *K. oxytoca*, *E. cloacae*, *S. sonnei*, *Y. colitica* and *Y. enterocolitica*. The occurrence of enteric bacteria and non-enteric bacteria is shown in Table 1.

Antimicrobial resistance spectrum

The antimicrobial resistance of some representative enteric bacteria isolated from shopping carts is shown in Table 2. Results indicate that all isolates were resistant to cloxacillin and erythromycin. All isolates were resistant to four types of antibiotics as a minimum. Some isolates were resistant to 5 tested antibiotics (for example some *E. coli* strains). Others were found to be resistant to 4 antibiotics (for example some *K. pneumoniae* strains) (Table 2).

Discussion

The results obtained from this current study demonstrated a variation in the load and type of heterotrophic bacteria on the surfaces of shopping carts used in all studied stores. In this study, the average bacterial concentration was higher than reported by other studies. The average bacterial load was 3.65×10^5 CFU/carts compared to 3.43×10^5 CFU/cart according to the study by Gerba and Maxwell (2012). These variations are more probably because of the level of sanitation of these shopping carts. It could also be attributed to the type of food that the shopper put in these tested shopping carts, the frequency of use, and the growth conditions. For instance, vegetables, seafood, fruits and raw meat, or frozen food items may have different impact on the nutrient levels, moisture,

Table 2: Antimicrobial resistance of the isolated enteric bacteria. The antibiotics used include ampicillin (amp), cefixime (cxm), ciprofloxacin (cip), cloxacillin (cxc), erythromycin (ery), gentamicin (gen), nalidixic acid (nal), and tetracycline (tet)

Bacterial isolate	N*	Antibiotics	T**
E. coli	8	amp, cxc, ery, gen, nal, tet	6
K. pneumoniae	4	amp, cxc, ery, tet	4
K. oxytoca	8	amp, cxc, ery, gen, tet	4
E. cloacae	4	amp, cxm, ery, cxc, tet	5
S. sonnei	7	amp, cxc, ery, tet	4
Y. colitica	1	amp, cxc, ery, nal	4
Y. enterocolitica	5	amp, cxc, ery, tet	4

*N: Number of resistant isolates
**T: The total number of resisted antibiotics

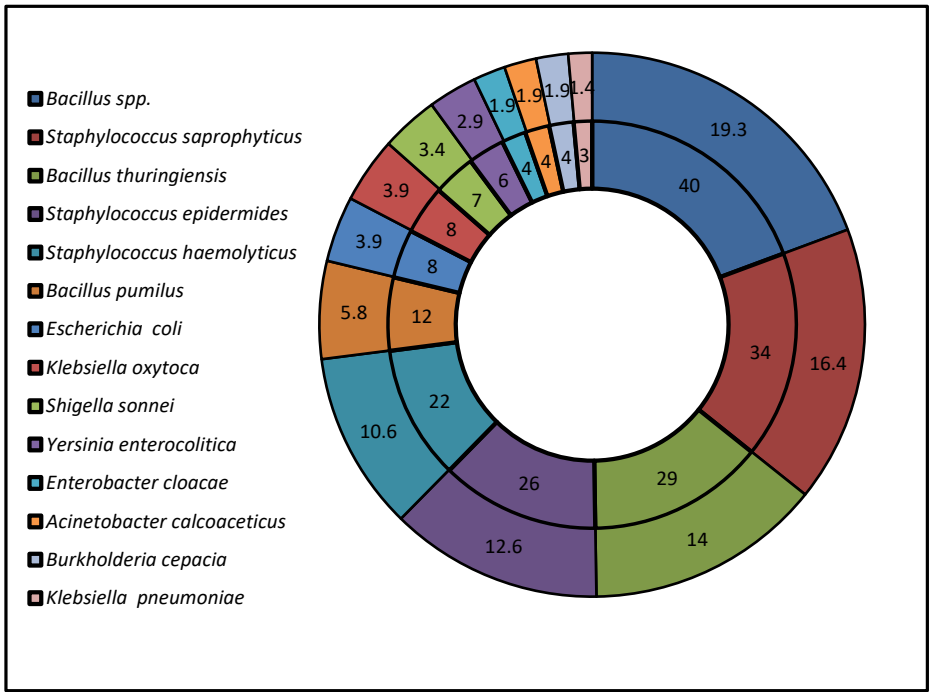

Fig. 2: Identification of bacteria and their abundance on shopping carts in the selected stores at A'Sharqiyah (the eastern region of the Sultanate of Oman). Outer circle sections represent the percentage of the detected species, whereas the inner circle sections represent the absolute number of isolates

and temperature of the shopping carts. These food types and their residues may give sufficient humidity and nutritional requirements to maintain microbial growth on the surfaces of these shopping carts. This was consistent with the previous studies (Gerba and Pepper 2009).

The overall assessment of the shopping carts samples analyzed bacteriologically indicated the presence of a high bacterial load. Some studies have illustrated a straight association between the bacterial population on shopping carts and the hazard of cross-transmission after a single hand-to-hand contact (e.g., Bellissimo-Rodrigues *et al*. 2017). The common incidence of enteric bacteria and *E. coli* on shopping carts suggests that the customers are prone to enteric bacteria regularly when using grocery shopping carts (Gerba and Maxwell 2012).

The detected bacterial species, like staphylococci, represents some resident microflora, which is attached to skin, and is resistant to taking away by regular washing. On the other hand, enteric bacteria frequently come from fecal material and are linked to low hygienic conditions. Enteric bacteria and *E. coli* that were found on the carts may have come from touching raw foods, animal wastes, other sources of fecal material, and contact with hands contaminated with feces or other body parts (diaper aged infants).

Results of a number of epidemiological reports have revealed that a risk of infectious disease from regular enteric bacteria was associated with the small children placement in shopping carts (Fullerton *et al*. 2007). Indeed, the occurrence of *Staphylococcus* sp. agrees with the study of Alghamdi *et al*. (2011). The high numbers of *Staphylococcus* sp. indicate poor sanitary conditions of the carts when we compare them to other common places that the community comes into contact. This likely enhances the

risk of acquiring a pathogenic organism. Interestingly, the obtained results showed the significance of sanitization and disinfection of shopping carts before use to evade/reduce the existence of *K. pneumonia*, which is known to be an opportunistic pathogen responsible for an elevated percentage (4–8%) of hospital-acquired infections (Podschun and Ullmann 1998). *Burkholderia cepacia* species represented the highest resistance strains against the tested antibiotics. Indeed, the *Burkholderia* can resist antimicrobials due to its outer membrane penetration fence. Most *Burkholderia* species have a modified lipopolysaccharide which causes intrinsic polymyxin resistance (Rhodes and Schweizer 2016). Similarly, *Acinetobacter calcoaceticus* is a common cause of nosomcomial infections worldwide and it is notable for its resistance against antibiotic such as carbapenems (Van *et al*. 2014).

These risks of infectious diseases transmitted via shopping carts can be reduced by applying shopping carts sanitization and disinfection program and by developing efficient planning to ensure scheduled cleaning of carts, and mainly to reduce the transmission of viruses like Covid-19. Disinfecting wipes available today contain chemicals like quaternary ammonium which efficient against many types of enteric bacteria (Block 2001). Moreover, disposable plastic covers are also an option. They are made to suit the hand contact area (for instance, the handle of shopping cart). After use, the covers can be discarded. Similar rules and legislations should be passed by authorities in Oman, to reduce the hazard of exposure to pathogens.

Conclusion

Supermarket's shopping carts seem to be one of the contaminated surfaces that the community may come into contact frequently in public facilities. The results of this study demonstrated that shopping carts my act as source for drug-resistant enteric bacteria and may act as a medium for transmitting heterotrophic bacteria between shoppers. These findings will enhance public awareness regarding shopping baskets and carts contamination through health education and promotion and conducting specialized public awareness sessions to improve public health education and promotion in the Sultanate of Oman in general and at A'Sharqiyah region in particular.

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Author Contributions

EH designed and supervised the study and drafted the manuscript. JJ designed and drafted the manuscript and prepared the article for publishing. IB reviewed the manuscript. AJ prepared the figures and tables. BA, HM, and NA collected the samples, performed bacterial cultivation, identification and antibiogram. AA co-supervised and revised the manuscript. WA, MM, MA, AA, MM, MW, SA and MA drafted and reviewed the manuscript and performed the background literature review for the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

Data Availability

The authors confirm that data supporting the findings of this study are available within the article.

Ethics Approval

No ethical approval was required to conduct the study.

References

Alghamdi A, A Suzanne, A Ahmad, F Hani, SH Hussein, J-H Asif (2011). Bacterial contamination of computer keyboards and mice, elevator buttons and shopping carts. *Afr J Microbiol Res* 523:3998–4003

Bellissimo-Rodrigues F, D Pires, H Soule, A Gayet-Ageron, D Pittet (2017). Assessing the likelihood of hand-to-hand cross-transmission of bacteria: An experimental study. *Infect Contr Hosp Epidemiol* 38:553–558

Blanco J, M Blanco, A Mora, J Blanco, J Gonzalez (2003). Verotoxin producing *Escherichia coli* (VTEC) in Spain: Prevalence, serotypes, and virulence genes of O157:H7 and non-O157 VTEC in ruminants, raw beef products, and humans. *Exp Biol Med* 228:345–351

Block SS (2001). *Disinfection, sterilization, and preservation*, 5th (Ed.). Lippincott, Williams and Wilkins, Philadelphia, Pennsylvania, USA

Carrascosa C, E Sanjuán, R Millán, S Martín, P Saavedra, A Raposo, C Rosario-Quintana, J Jaber (2019). Is the use of supermarket trolleys microbiologically safe? Study of microbiological contamination. *J Appl Anim Res* 47:17–23

Catherine G (2006). *Wheeling Food Products Around the Store and Away: The Invention of the Shopping Cart*, pp:1936–1953. CSI Working Papers Series 006, Centre de Sociologie de l'Innovation (CSI), Mines ParisTech, Paris, France

Fullerton KE, LA Ingram, TF Jones, BJ Anderson, PV McCarthy, S Hurd, B Shiferaw, D Vugia, N Hubert, T Hayes, S Wedel, E Scallan, O Henao, F Angulo (2007). Sporadic *Campylobacter* Infection In Infants. A Population-Based Surveillance Case-Control Study. *Pediatr Infect Dis J* 26:19–24

Gerba C, S Maxwell (2012). Bacterial contamination of shopping carts and approaches to control. *Food Prot Trends* 32:747–749

Gerba CP, IL Pepper (2009). Domestic and indoor microbiology: In: *Environmental Microbiology*, pp:555–563. Maier RM, IL Pepper, C Gerba (Eds.). Academic Press, San Diego, California, USA

Irshaid FI, JH Jacob, AS Khwaldh (2014). Contamination of the handles and bases of shopping carts by pathogenic and multi-drug resistant bacteria. *Eur Sci J* 10:27

Jacob J, F Irshaid (2015). Toluene biodegradation by novel bacteria isolated from polluted soil surrounding car body repair and spray painting workshops. *J Environ Prot Sci* 6:1417–1429

Jacob JH, FI Irshaid, M Alhalib (2016). Estimation and Identification of Airborne Bacteria and Fungi in the Outdoor Atmosphere of Al-Mafraq Area. *Jor J Biol Sci* 9:3–10

NCCLS (2000). *Performance Standard for Antimicrobial Disk Susceptibility Tests; Approved Standards*, p:26, 9th edn. National Committee for Clinical Laboratory Standards (NCCLS), Villanova, PA Publication, M2–A5, USA

Podschun R, U Ullmann (1998). *Klebsiella* spp. as nosocomial pathogens: Epidemiology, taxonomy, typing methods, and pathogenicity factors. *Clin Microbiol Rev* 11:589–603

Reynolds KA, P Watt, S Boone, C Gerba (2005). Occurrence of bacteria and biochemical markers on public surfaces. *Intl J Environ Heal Res* 15:225–234

Rhodes KA, HP Schweizer (2016). Antibiotic resistance in *Burkholderia* species. *Drug Resist Updat* 28:82–90

Van TD, QD Dinh, PD Vu, TV Nguyen, CV Pham, TT Dao, CD Phung, HT Hoang, NT Tang, NT Do, KV Nguyen, H Wertheim (2014). Antibiotic susceptibility and molecular epidemiology of Acinetobacter calcoaceticus-baumannii complex strains isolated from a referral hospital in northern Vietnam. *J Glob Antimicrob Resist* 2:318–321