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Full Length Research

A Literature Review of Health Risks Associated with Enteric Pathogens in Raw Milk in Nigeria

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Abstract: Raw milk is milk (secreted by mammals and used as food by human beings) that has not been subjected to any form of processing intended to alter its quality or composition characteristics. The methodology used in this study includes extensive review of the literature of previous researchers sourced from secondary sources. Such secondary data explored extensively for the purpose of this study included: textbooks, periodicals, journal, and internet materials that amplify the vitality of some of the enteric pathogens associated with milk Production. Other means of secondary sources were from archival materials relating to milk production and enteric pathogenesis. This literature review aims to investigate the archival literature of past authors regarding the prevalence of enteric pathogens in raw milk. The occurrence of some of these pathogens *(Pseudomonas sp. ,E.coli, Proteus, Klebsiella, Salmonella and Enterobacter*) in raw milk are due to several factors such as animal health, poor milking practices, and poor animal waste management. Taken together, findings from extant literature revealed that in order to ensure safety of raw milk, regulatory authorities should establish guidelines and standards based on research findings to cover the entire raw milk chain to alleviate the risk associated with disease outbreak of raw milk.
Keywords: Raw milk: Colony: Samples: Cattle: Gastroenteritis: Health: Nutrition: Nigeria.

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1.0 Introduction of the Study

Raw milk is milk that has not been heat treated. Milk is a complex biological fluid and by its nature, a good growth medium for many micro- organisms. Because of its specific production it is impossible to avoid contamination of milk with micro-organisms therefore the microbial content of milk is a major feature in determining its quality (Rogelj, 2003). Bacterial contamination of raw milk can originate from different sources: air, milking equipment, feed, soil, feces and grass (Coorevits et al., 2008). The number and types of micro-organisms in milk immediately after milking are affected by factors such as animal and equipment cleanliness, season, feed and animal health (Rogelj, 2003). It is hypothesized that differences in feeding and housing strategies of cows may influence the microbial quality of milk (Coorevits et al., 2008). Rinsing water for milking machine and milking equipment washing also involve some of the reasons for the presence of a higher number of micro-organisms including pathogens in raw milk (Bramley, 1990). After milking, milk is cooled, which additionally influence the dynamic of microbial process (Rogelj, 2003).

Milk and milk products provide a wealth of nutritional benefits however; raw milk can harbor dangerous microorganisms which may pose serious health risks to humans. Over 200 known diseases are transmitted through eating food contaminated by a variety of agents including bacteria, parasite, viruses, and fungi (Oliver et al., 2005)

Milking and milk handling practices in informal sector are done commonly without observing hygienic practices. It is a common practice to vend milk in inappropriate milk holding and storage equipment (Okorie, 2014). Such practice poses a threat to public health as chances of consuming unsafe milk are very high. Since there is little or no quality control for milk produced and handled in the informal channels, there is potential risk of contamination by zoonotic pathogens, adulterants, enteric pathogen and antimicrobial drug residues hence public health risks to consumers (Kurwijila et al., 2006). It is well known that milk-borne diseases are much higher among communities that frequently consume raw milk from communally grazed herds (Arimi et al., 2005), since it's a common practice to drink raw unpasteurized milk in some parts of Nigeria. Some people prefer drinking raw milk believing that they have advantages and value such as taste and convenience over the pasteurized one (Altalhi & Hassan, 2009; Angulo et al., 2009).

Enteric pathogens involved in causing food borne diseases due to the consumption of raw milk include *Escherichia coli, Listeriamonocytogenes*, *Salmonella, Campylobacter, Proteus, Klebsiella* and *Clostridium botulinum*. If these pathogenic bacteria are present in raw milk, it is of major public health concern, especially for those individuals who drink raw milk frequently (Chye et al., 2004). Salmonella food poisoning is one of the most common and widely distributed diseases in the world, estimated to cause 1.3 billion cases of gastroenteritis and three million deaths worldwide (Ohud et al., 2012). E. coli is frequently a contaminating organism compared to other microbes and it is a reliable indicator of fecal contamination (Kumar & Prasad, 2010). E. coli is mainly abundant in the intestinal tract of most mammalian species, including humans and cattle. Most E. coli are commensals, but some are known to be harmful, whereby causing severe intestinal and extra intestinal diseases in humans (Kumar & Prasad, 2010). In the raw milk value chain, milk producers, vendors and shop outlets can influence the prevalence of harmful pathogens in milk through poor animal husbandry, adulteration, washing equipment, udder and hands with unsafe water, storing and transportation in unhygienic condition and abuse of storage temperature. The aim and objective of this study was to condect an extensive literature review of health risks associated with enteric pathogens in raw milk sold at Auchi, Aduwawa, Asaba, Agbor and Warri in Nigeria.

2.0 Literature Review

2.1 Dairy Production Systems

A study by Ruegg (2003) studied the prevalence of *Salmonella spp.* and *Escherichia coli* (*E. coli*) in milk value chain in Arusha, Tanzania. A total of 75 raw milk samples were collected from smallholder dairy farmers, street vendors and outlet shops in Arusha and Arumeru districts. *Salmonella* and *E. coli* were detected in 28/75 (37.33%) and 68/75 (90.67%) samples, respectively. Bangata ward in Arusha showed relatively high prevalence of *Salmonella spp.* (42.11%) while Akeri ward in Arumeru showed relatively low prevalence (31.58%). In milk value chain, the highest prevalence was observed in street vendors (43.75%) while the lowest prevalence was in dairy farms (33.33%). Mean count for *E. coli* from milk producers, vendors and shops were 3.0×10^3, 8×10^3 and 6.6×10^3 cfu/mL, respectively, indicating a significant ($p < 0.05$) increase in *E. coli* load along the chain. Furthermore, confirmatory test showed that *Salmonella* isolates were predominantly identified as *Salmonella enterica*serovarArizonae. Besides, *Salmonella* and *E. coli*, other enterobacteria detected were *Enterobacter cloacae, Klebsiella pneumonia*, and *Serratiamarcescens*. Taken together, qualitative and quantitative findings revealed that poor animal husbandry, poor hygienic practices, lack of refrigeration and less awareness of the zoonotic pathogens had a significant impact on the prevalence of detected bacteria, posing a public health risk.

A study done by Olatunji et al. (2012) analyzed raw milk from four different local farmers within Gwagwalada Area Council (FCT) Abuja, the milk were assessed to determine the bacterial load of the milk. The result revealed that raw milk sampled contained various bacteria species which include species of *Bacillus subtillis*, *Escherichia coli, Staphylococcus aureus, Salmonella spp, Lactobacillus spp, Streptococcus spp*. The total viable bacteria counts ranged from 1.0×10^6 - 5.6×10^7cfu/ml, while *Bacillus subtillis* has the highest frequency of occurrence (26.84%) followed by *Escherichia coli* (24.39%), *Staphylococcus aureus* (24.39%), *Salmonella spp*. (17.06%), *Lactobacillus spp*. (4.88%) and *Streptococcus spp.* (2.44%).

Contaminated milk reduces the chances of high quality production of milk and milk- based products, and thereby, hit the economy badly. In a study by Ruegg (2003) studied raw milk quality and analyzed from different regions of Dehradun city in Uttarakhand. The study revealed the bacterial load in raw milk samples and their antibiotic sensitivity. Fifty raw milk samples were collected from different dairy owners in Dehradun city. The microbial analysis of raw milk samples revealed dominant micro flora as *E.coli* > *Micrococcus* >*Lactobacillus sp.*> *Salmonella sp.*> *S. aureus* >*Klebsiella*species. *E.coli* was found to be resistant to tetracycline and intermediate to chloramphenicol, Salmonella was resistant to penicillin and intermediate to streptomycin and tetracycline while Klebsiella was resistant to penicillin, chloramphenicol, erythromycin, intermediate to streptomycin and tetracycline. The bacteria found resistant are a threat to mankind.

(1) Extensive or Traditional system

Under the extensive system, the producers are generally scattered among rural communities at some considerable distance from the urban centers (Okorie, 2014). The stock used consists of a collection of cows sometimes goats and sheep. The cows are not selected for high milk production or any of the other characters derivable in a good dairy animal. Milking is not carried out at regular intervals and very often there is no record for milk produced by each cow. There are no cultivated pastures on which to feed the animals. The animals rely on grazing on the open range grounds with the change of seasons. In most cases, this development results in a very low level of production.

(2) Intensive (modern) system

This system involves the use of dairy animals specialized for milk production. This involves the investment of considerable capital. The size of the dairy herd could vary from 50-100 cows for small scale operations and up to 500-1000 cows for medium size operation. The large scale operation has more than 1000 cows. The animal used for this operation are high yielding European type of breeds e.g. Friesian. In some urban dairies in Nigeria, crosses of European breeds with indigenous cattle, selected indigenous cows are used in urban dairies in Nigeria. Breeding records are kept and selection for high milk yield is intensively carried out. The milk is regularly tested for quality. The animals are fed regularly on cultivated pastures usually green soiled or zero-grazed. The animals are housed and milking is usually done in a dairy Parlor under hygienic conditions. There is a considerable degree of mechanization in most of the operations. The animals are subjected to regular veterinary inspection to prevent and cure diseases.

2.2 Breeds of Cattle Used in Milk Production

In most temperate countries, milk comes mainly from domesticated cattle which have over several generations become specialized for milk production.

Holstein-Friesian: It originated from Netherlands but it has spread to other parts of the world, especially where emphasis has been on milk production. The color is black and white or red and white. World's highest producing dairy animal. Holstein-Friesian is a cross between the black cattle of the Batavians (Holstein) and white cows of Friesian bred to produce the most efficient milk with limited feed resources.

Figure 1: Friesian cow

Jersey: Jersey cattle are a small breed of dairy cattle. Originally breed in the Channel Island of Jersey. Jerseys come in all shades of brown, from light tan to almost black frequently fawn in color. All purebred Jerseys have a lighter band around their muzzle, a dark switch (long hair on the end of the tail), and black hooves.

Figure 2: Jersey Cow

2.3 Indigenous Dairy Breeds

Most of the indigenous breeds particularly, the Southern breeds offered no prospect for milk production due to poor performances in experimental stations (Okorie, 2014). Nevertheless, some of theNorthern breeds offer some prospect for milk production because of the available figures on yield as well as the large number of the breed e.gKuri, Shuwa Arab, White Fulani.

Kuri: The gigantic bulbous horns are an unmistakable trait of the Kuri. It is also called Lake Chad Cattle or Buduma Cattle. These cattle are native to the shores of Lake Chad where Cameroon, Chad, Niger and Nigeria join. The Kuri are believed to be descended from the Hamitic Longhorn cattle and have been herded by the Buduma and Kuri peoples for centuries

Figure 3: Kuri Cattle

Shuwa Arab (Wadara Cattle): This is found in North East part of Nigeria. Wadara cattle are medium-sized, lightly built cattle, and are usually dark red, black, pied or brown. They are indigenous cattle of Borno and are referred to by the Koyam and related pastoralists as ‘our’ cattle.

Figure 4: Shuwa Arab Cattle

White Fulani (Bunaji) Cattle: This is the most widely distributed of all Nigerian cattle breed. It is found in Nigeria particularly Kano, Bauchi and Katsina province. It constitutes 50% of total cattle production. The coat color is white with black points on the ears, muzzle and feet and tip of tail. It is used for milk production throughout the ecological zones in the country.

Figure 5: White Fulani Cattle

2.4 Occurrence of Pathogens in Raw Milk

The international literature indicates the occurrence of a number of enteric pathogenic bacteria in raw milk, including: *Bacillus cereus*, *Campylobacter* spp.,*pseudomonas* spp., pathogenic *E. coli*, *L. monocytogenes*, *M. bovis*, *Salmonella* spp., *S. aureus*, *Enterobacter, Proteus* and *Yersinia* spp.*(* Claeys*et al*., 2013; FSANZ, 2009).

2.5 Milk Production and Safety

Most of the human enteric pathogens being assessed can originate from clinically healthy animals from which milk is obtained. Pathogenic bacteria can enter milk from several animal sources including direct passage from blood to the milk, mastitis, and fecal contamination during or after milking; from human skin; and the environment (LeJeune and Rajala-Schultz, 2009). Dairy farms on their own are an important reservoir of food borne pathogens (e.g. Olver*et al*., 2005). The relative importance of the various sources of contamination depends on the farming practices and may be different for each of the pathogens.

2.5.1 Animal Husbandry

Dairy production practices are constantly changing, with a general trend towards management of animal's off-pasture. "Dairy farm practices are evolving in response to growing intensification, in attempts to limit urinary nitrogen deposition on paddocks (which leads to nitrate leaching into waterways), safeguarding soils /pasture in winter and managing animal welfare better. Key changes include growing use of feed pads, stand-off pads and sheltered housing. In these systems cows are much more exposed to fecal contamination, particularly their feet, legs, teats udder and tail. The skin of cows is increasingly contaminated with fecal coliform bacteria. The feces further with higher coliform content. A likely risk is an increase in coliform mastitis. Thus, unclean teats at milking and more coliform mastitis will result in an overall increase in fecal coliform bacteria in raw milk. Appropriate management of coliform contamination of teats and raw milk will be increasingly necessary.

Poor feeding practices can result in contaminated feed which may increase the transmission and carriage of these enteric pathogens. Improved control of storage, preparation and distribution of feed can all help to reduce contamination. Uncertainty exists as to how differences in milk sourcing practices between small-scale and large-scale producers affects the probability of pathogens being present in the raw milk used for human consumption. For example, pooling milk from many individual cows for larger volumes of milk might increase the probability of having pathogens in any portion of milk sold, but the organism would be diluted. On the other hand, where there are fewer animals the lack of dilution might lead to intermittent high levels of contamination in the smaller volume.

2.5.2 Animal Health

The relationship between bacteria and ill-health in adult dairy cattle is highly variable. There is evidence of the emergence of a virulent strain (ST-8) in the US (Sahin*et al.*, 2012), that has been the cause of raw-milk associated outbreaks.*Salmonella* spp. is a major cause of ill-health in adult dairy cattle (Low *et al.*, 1997), and may be shed in the feces of both diseased and unaffected individuals. It follows that the prevention and control of these agents through appropriate herd health management schemes will not only reduce the incidence of clinical disease, but also reduce herd prevalence and fecal shedding in clinically normal animals that may be a source of contamination of raw milk (Ruegg, 2003).

2.5.3 Milking Practices

Poor, unhygienic milking practices, soiled udders and teats, damaged teats, and poor operator hygiene can all lead to increased contamination of raw milk (Blowey and Edmondson, 2010). A study of 235 dairy herds on Prince Edward Island (PEI) identified pre-milking udder preparation as an important determinant of a range of different bacterial counts in milk (Elmoslemany*et al.*, 2010). The amount of soiling on the teats prior to milking and the method of udder preparation prior to milking were associated with total aerobic count (TAC). This is consistent with other reports from the same authors (Elmoslemany*et al.*, 2009) that show a similar positive association between udder hygiene and bacteria in bulk tank milk, and the view that dirty udders and teats are an important source of enteric bacteria pathogen in milk (Pankey, 1989; Murphy and Boor, 2000; Galton *et al.*, 1986; Galton *et al.*, 1984). The association may be attributed to inadequate cleaning of heavily contaminated cattle, due to time pressure (Reneau and Bey, 2007) or the indirect effects of poor udder and teat hygiene on mastitis (Schreiner and Ruegg, 2003).
Teat washing and drying compared to washing but not drying was associated with a five-fold reduction in total bacterial account (TBC) data cited in (Blowey and Edmondson, 2010). Other studies have also shown an association between reduced bacterial contamination of milk and the use of certain types of pre-milking teat dips and manual drying (Galton *et al.*, 1986; Magnusson *et al.*, 2006). Together, measures to improve milking hygiene appear to offer good opportunities to reduce raw milk contamination, but this requires the adoption of time-consuming practices and attention to detail. The microbiological risk assessment of raw cow's milk conducted by FSANZ indicated that teat cleaning would reduce the *E. coli* concentrations in raw milk by approximately 1 log.

2.5.4 Regular Microbiological Monitoring of Milk Production

Testing and removal of pathogen containing lots can result in a lower prevalence of contaminated bulk raw milk. While conventional microbiological monitoring based on culture is too slow to provide a timely indication of bacterial contamination to enable action to be taken before milk is released for sale. Testing for the presence of specific pathogens in milk using conventional cultural techniques could be implemented on a sporadic basis to identify farms with repeated contamination.

2.5.5 Temperature Control of Raw Milk after Milking

Warmer ambient temperatures have been associated with higher bacterial contamination of bulk tank milk, including higher coliform counts (Elmoslemany*et al.*, 2010) highlighting the need for good temperature control during storage of bulk milk. It is important to take into consideration that organisms such as *Listeria* spp. are psychotropic and will grow at refrigeration temperatures, and other organisms such as *E. coli* and *Salmonella* spp. can multiply at temperatures of about 8^0c. Another important aspect of the mitigation strategy for reducing the risk of raw milk consumption to human health is ensuring that sale of raw milk commences only after the milk is cooled below 6^0c.

2.5.6 Equipment Cleaning and Maintenance

The PEI study also identified bulk tank cleaning and hygiene as a risk factor for high bacterial counts and identified particular practices that could help to reduce biofilm formation on milking equipment and contamination of raw milk. Manual cleaning, along with lower temperatures and lower frequency of detergent and acid use was associated with increased bacterial contamination of bulk tank milk (Elmoslemany*et al.*, 2010; Elmoslemany*et al.*, 2009). Requirements for cleaning will be critical whenever vending machines are used for raw milk sales, provide further opportunities for minimizing biofilm formation.

2.5.7 On-Farm Waste Management
Contaminated animal drinking water and poor management of dairy shed and other effluent can lead to increased pathogen cycling in dairy farms and increased within and between-farm transmission of infectious agents. Studies conducted in New Zealand and elsewhere have shown variable survival rates of pathogens in the farm environment, but also demonstrated the importance of good management of manure and effluent to avoid contamination of waterways (Sinton *et al.*, 2007).

2.6 Some Of The Enteric Pathogens Associated With Milk Production Include:

2.6.1Escherichia Coli
E. coli according to Edwards18 is motile, Gram-negative, nonspore-forming bacillus. Typically, it produces positive tests for indole and methyl red but negative for lysine, citrate and vorgesproskaeur. It is positive for decarboxylase and mannitol fermentations. It produces gas from glucose as well as lactose.It has typical colonial morphology with an iridescent “sheen”on differential media such as Eosine Methylene Blue agar. Colonies on MacConkey’s medium are smooth, glossy, translucent and rose pink. It is impaired or totally inhibited on deoxycholate citrate agar (DCA). *E. coli* is distinguished from other coliforms by its ability to form gas from lactose at 44^0c

2.6.2 Proteus Species
Proteus vulgaris, *Proteus mirabilis*, *P. morgana* and *P. retagri.* Members of this group deaminate phenylalanine, they are motile, grow on potassiumcyanide medium (KCN) and ferment xylose. Cultures produce fishy smell. Proteus species move very actively by means of a peritrichous flagella, resulting in “swarming” on solid mediaunless it is inhibited by chemicals, such as phenylalaninealcohol or cystine-lactose-electrolyte-deficient medium.
Proteus species are highly motile, and this makes them“swarm” actively in growth media. They are urease-positive
Proteus mirabilis is more susceptible to antimicrobial drugs, including penicillin, than members of the group.

2.6.3Citrobacter
Members of this genus are citrate-positive capable of growth in potassium cyanide medium and differ from *Salmonella* in that they do not decarboxylate lysine. They ferment lactose veryslowly if at all.

2.6.4 Salmonellae
These do ferment glucose and mannose without producing gas, but do not ferment lactose or sucrose. Most of them produce hydrogen sulphide gas in Triple Sugar Iron agar. They are often pathogenic to humans or animals when ingested.

2.6.5 Shigellae
These are non-motile and usually do not ferment lactose but do ferment other carbohydrates producing acid but not gas. They do not produce hydrogen sulphide gas. The four *Shigella* species (*Shigella flexineri*, *S. dysentricus, S. boydii* and *S. sonnei*) are closely related to *E. coli*. Many share common antigens with one another and with other enteric bacteria.

2.6.6 Klebsiella, Enterobacter* and *Serratia Species
Klebsiella species exhibit mucoid growth, large polysaccharidecapsules and lack motility and usually give positive tests for lysine decarboxylase and citrate. Most *Enterobacter* species give positive tests for motility, citrate and ornithinedecarboxylase and produce gas from glucose. *Enterobacteraerogenes* have small capsules.

2.7 Enterobacterial Pathogenesis
The harmful effects caused by enterobacterial pathogens to man and animals result after successful invasion and final establishment in the host system resulting in an immunological interactions manifested by a specific disease type presentation.This is mostly a consequence of strict and opportunistic pathogen actions.

2.8 Gastroenteritis
This is defined accordingly as the inflammation of the mucous membrane of the gastro-intestinal tract due to diet error and/or bacterial infection. It may also be due to toxins and allergic reaction. Gastroenteritis is one of the disastrous communicable infections occurring all over the world more especially in developing countries where the standard of hygiene and economy is very low. It was maintained that poor environment sanitation including low

Control of flies facilitated the introduction of bacterial into foods and water. A warm humid climate with lack of adequate storage facilities (Refrigeration and smoking) act as well. Both adults and children suffer from the disease but infants are more susceptible due to probably immature immunological responses and malnutrition especially in non-breast fed infants.

This was reiterated to be due to their slow rate of mucosal epithelial regeneration hence low production of local immunoglobulin A. As a consequence, gastroenteritis is probably responsible for the killing of more children throughout the world than any probably responsible single disease. Further, under nutrition makes infants more susceptible to viral and bacterial intestinal pathogens and render their effects more ravaging. Intake of toxins such as methyl chlorides, arsenic etc., leads also to uncountable cases of gastroenteritis. It was confirmed that many of the cases are due to emerging. *E. coli* enteropathogenic *E. coli* (EPEC), 0157:H7 enterotoxigenic *E.coli* (ETEC), enteroinvasive *E. coli* (EIEC), *Shigella dysentricus, Salmonella paratyphi, Klebsiella, Proteus, Citrobacter*, *Vibrio* and a vast number of other *Enbterobacteriaceae. Faecalis* are also very critical withrespect to gastroenteritis.

3.0 Research Methodology of the Study

The aim and objective of this study was to conduct an extensive literature review of health risks associated with enteric pathogens in raw milk sold at Auchi, Aduwawa, Asaba, Agbor and Warri in Nigeria. Data for the study were collected from secondary sources. Secondary data explored extensively for the purpose of research included: textbooks, periodicals, Journal, and internet materials that amplify the vitality of some of the enteric pathogens associated with milk Production. Other means of secondary sources were from archival materials relating to milk production and enteric pathogenesis.

4.0 Conclusion of the Study

The aim and objective of this study was to conduct an extensive literature review of health risks associated with enteric pathogens in raw milk sold at Auchi, Aduwawa, Asaba, Agbor and Warri in Nigeria. However, this study found that after an extensive review of extant literature that the presence of these enteric pathogens (*Salmonella sp., E. coli, Pseudomonas sp.*, *Enterobacter,* and *proteus sp.*) in raw milk indicates contamination due to poor animal husbandry and hygienic practices, inappropriate transportation and storage facilities and use of unsafe water, the highest prevalence of disease causing microorganisms was observed in street vendors and least prevalence was in dairy farms. Also, the practice of drinking raw unpasteurized milk is hazardous because it increases the risk of acquiring zoonotic diseases. The findings of this study provide insights into the enteric pathogen associated with consumption of raw milk. In order to ensure safety of raw milk, regulatory authorities should establish guidelines and standards based on research findings to cover the entire raw milk chain to alleviate the occurrence of these pathogens in raw milk which is of concern as it is a public health risk.

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