Review Article

Prevalence of Antibiotic Resistant Gram negative Bacteria in the Street Vended Foods of Bangladesh: An Overview

ABSTRACT

Background:Street vended foodscontaminated with antibiotic resistant bacteria poses a great public health concern in developing countries like Bangladesh as foodborne diseases caused by such bacteria are difficult and sometimes impossible to treat. The aim of this review is to investigate the present scenario of the antibiotic resistance status of five selected Gram negative bacteriaisolated from a variety of street vended foods of Bangladesh.

Methodology: A methodical literature search was performed to identify relevant studies on Google Scholar, Science Direct and Research Gate using suitable keywords arranged in different manners to produce a meaningful search string.Weighted mean resistance was calculatedto evaluate the resistance status from 20 studies selected through the PRISMA procedure.

Results:*Escherichia coli*, *Klebsiella* spp., *Salmonella* spp., *Pseudomonas* spp. and *Vibrio* spp. showed relatively low resistance towards imipenem and gentamicin, whereas the antibiotics of penicillins and macrolides classes listed in this review were mostly ineffective. Relatively high resistance was found against tetracycline, vancomycin, and rifampicin.

Conclusion: A considerable number of bacterial isolates present inthe SVF are resistant to most of the commonly used antibiotics.Therefore, there is an urgent need for public awareness along with a robust national action plan to combat antibiotic resistance, before the situation worsens.

Keywords: Street vended foods, Bangladesh, Gram negative bacteria, Contamination, Antibiotic resistance.

1. INTRODUCTION

The World Health Organization (WHO) has defined Street Vended Foods(SVF)as, “Foods and beveragesprepared and/or sold by vendors in streets and other public places for immediateconsumption or consumption at a later time without further processing or preparation”. Due to inexpensiveness, unique flavor, variation and other conveniences the demand for street vended foods is increasing among urban people [1]. There are about 200,000 street food vendors in Dhaka city alone and the number is growing due to rapid urbanization [2,3]. Most vendors set up their stalls near bus terminals, busy roads, in front of schools, markets and railway stations in hopes of high potential customers. Vending carts are also placed by the side of municipal drains and sewage which attract insects and flies [2]. All these places have limited access to basic sanitary facilitiessuch as running water, garbage disposal and clean toilets which puts the cleanliness of foodpreparing places and personal hygiene of vendors in question [4]. Inappropriate food handling, contaminated raw materials, cross contaminants from utensils and equipment are important sources of bacterial contamination in street foods. Contaminated foods act as a vehicle for transmitting foodborne diseases like diarrhoea, cholera, typhoid fever and food poisoning [5]. InBangladesh, about 30 million people suffer from food borne illnesses each year and approximately 2.2 million people including many children die of diarrhoeal diseases [6]. To battle against infections such as these, antibiotics are a blessing to human civilization that

have saved millions of lives [7]. However, widespread availability and uncontrolled application of antibiotics in humans, food-producing animals, veterinary practices, and agriculture are causing a gradual uprising of antibiotic resistant bacteria [8,9]. The foodborne diseases become fatal when the pathogens causing them are also antibiotic resistant which elevate the duration of hospitalization,cost of treatment and the risk of mortality [10]. Antibiotic resistance is a property of bacteria that confers the capacity to inactivate or exclude antibiotics, or a mechanism that blocks the inhibitory or killing effects of antibiotics [11]. Resistance mechanisms may develop over months or years as the result of many years of inappropriate application of antibiotics in human, agriculture, aqua culture and in various other sectors [12,13].Once accomplished, a single mechanism can allow a bacterium to become multi-drug resistant [14]. Resistance to different antibiotic classes may also be caused by the intrinsic resistance characteristics of bacteria [15].WHO (2017) report shows a serious lack of new antibiotics under development to keep pace with the threat posed by the resistant bacteria. As a result, the world is gradually running out of antibiotics and approaching a time when people will dread common infections [16]. Developing countries like Bangladesh are more vulnerable to this issue for their underprivileged healthcare infrastructure [17].Therefore, this review was conducted to reveal a comprehensive scenario of antibiotic resistance status of *Escherichia coli*, *Klebsiella* spp., *Salmonella* spp., *Pseudomonas* spp. and *Vibrio* spp. isolated from a wide range of street vended foods including drinking water, fruit juices, ready-to-eat (RTE) fruits and vegetables, fried items and a variety of other traditional items available in Bangladesh.

2. METHODOLOGY

A methodical literature search was performed to identify studies associated with antibiotic resistance of Gram-negative bacteria found in various street vended foods of

Bangladesh.Multitudinous searches were conducted on Google Scholar, ScienceDirect and ResearchGate to identify relevant studies using keywords such as microbial quality, street food, antibiotic resistant bacteria, Bangladesh, RTE foods etc. arranged in different manners to produce a meaningful search string. Studies were also added through manual searching from the INFS Library of the University of Dhaka. Figure 1 shows the PRISMA procedure through which 20 studies were selected to be used in this review article[18]. These studies were thoroughly revised by the authors and the extracted data was cross-checked multiple times.

The criteria of data extraction were publication year, study location, sources, antibiotic susceptibility testing method, antibiotic susceptibility testing standard, type and the number of bacteria identified and resistance status of the bacteria identified, as depicted in table 1. Thepercentages of resistance were calculated by following the procedure used by Sabuj et al. 2018 for those studies where percentages were not mentioned but sufficient data was available [19]. The resistance status of each bacterial genera to different antibiotics is presented as the weighted meanresistance (percentage), combining all of the studies. The weighted mean resistance is calculated so that the resistance values corresponding to a larger number of isolates can contribute more towards the final mean. Data collection and analysis were conducted on Microsoft Word 2016 and Microsoft Excel 2016.

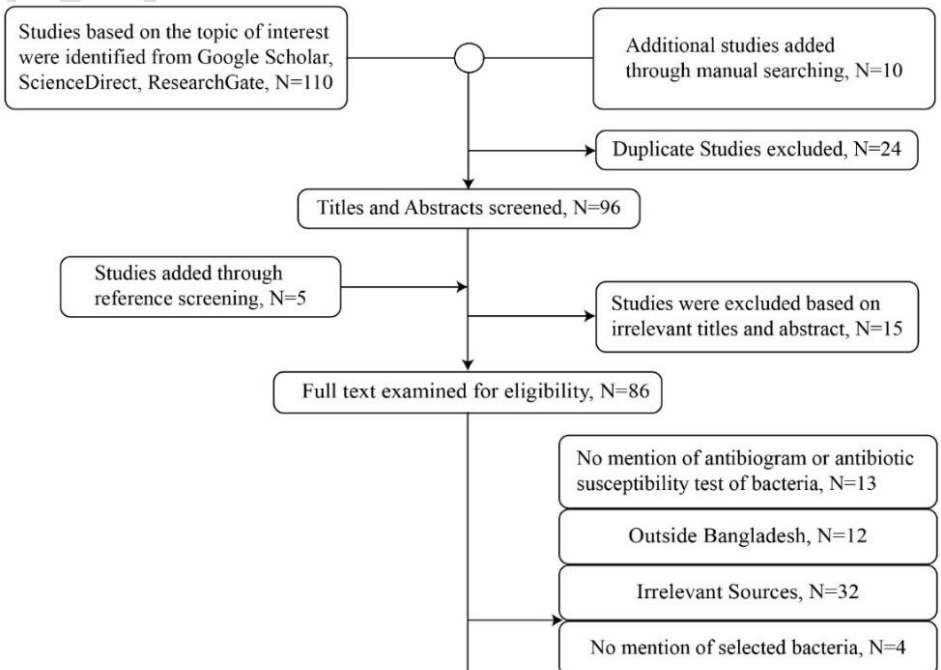

Figure 1: The PRISMA procedure used in paper selection.

3. RESULT

Antibiotic resistance pattern of *Escherichia coli*, *Klebsiella* spp., *Pseudomonas* spp., *Vibrio* spp. and *Salmonella* spp. analyzed in this review article are extracted from the studies published between 2011-2019. Weighted mean was calculated only if antibiotic susceptibility test (AST) data of a significant number of isolates (ten or more) of the bacteria to a specific antibiotic were found after combining all the studies (Table 2). The resistance status can be classified into: i) high resistance (>50% resistant isolates), ii) intermediate resistance (20-50% resistant isolates) and iii) low resistance (<20 % resistant isolates)[20].

All five bacteria showed high resistance to amoxicillin. All bacteria except *Vibrio* spp. showed high resistance to vancomycin and erythromycin and low resistance to gentamycin. Most of the bacteria showed high resistance to ampicillin, tetracycline, azithromycin and rifampicin. All the isolates of *Escherichia coli* and *Pseudomonas* spp. were resistant to penicillin. *Escherichia coli*, *Klebsiella* and *Pseudomonas* spp. were completely susceptible towards ceftriaxone, chloramphenicol and neomycin respectively. The bacteria were found to have a varying degree of resistance (high, low & intermediate) to quinolones (nalidixic acid, ciprofloxacin). *Escherichia coli* and *Pseudomonas* spp. showed relatively low resistance towards ceftriaxone, a

third generation cephalosporin, compared to cephalexin, a first generation cephalosporin. However, *Salmonella* spp. showed relatively high resistance to ceftriaxone. Low or intermediateresistance was observed towards the aminoglycosides class (neomycin, kanamycin, streptomycin, and gentamycin), carbapenems class (imipenem), chloramphenicol and doxycycline.

Table 1: Characteristics of the Studies Included in the Review

Class	Frequency of papers (total n=20)	Percentage of papers (%)	Reference
Publication Year			
2011-2013	3	15	[21–23]
2014-2016	3	15	[24–26]
2017-2019	14	70	[9,19,27–38]
Antibiotic Susceptibility Testing Methods			
Disk Diffusion Method	20	100	[9,19,21–38]
Antibiotic Susceptibility Testing Standards			
Clinical Laboratory Standards Institute (CLSI)/National Committee for Clinical and Laboratory Standards (NCCLS)	10	50	[9,19,23,27,29,30,33,35,36,38]
Not mentioned	10	50	[21,22,24–26,28,31,32,34,37]
Food Type			
Juices e.g. sugarcane, lemon, papaya, woodapple, mango, orange etc.	4	20	[24,29,30,36]
Ready to Eat Vegetables & Fruits e.g. cucumber, carrot, hog plum etc.	2	10	[21,38]
Drinking Water	2	10	[28,35]
Traditional and Fried Street Food e.g. chatpati, jhalmuri, fuchka, shingara, samosa, chitoipitha etc.	7	35	[19,25,26,31,32,34,37]
Mixed Food Groups	5	25	[9,22,23,27,33]
Bacteria			
Escherichiacoli	16	80	[19,21–28,30–34,37,38]
Vibrio spp.	5	25	[24,28,29,34,36]
Salmonella spp.	11	55	[9,19,21,22,24,25,27,28,33,35,37]
Klebsiella spp.	12	60	[21,22,24–26,28,29,32–34,36,37]
Pseudomonas spp.	5	25	[22,24,26,34,35]

Table 2: Antibiotic Resistance Status (percentage) of Five Selected Gram-negative Bacteria.

Class and Name of Antibiotics														
Aminoglycosides			Quinolones		Macrolides		Cephalosporins		Tetracyclines		Carbapenems	Glycopeptides	Others	
STR (10µg)	NEO (30µg)	CN (10µg)	CIP (5µg)	NA (30µg)	ERY (10µg)	AZM (15µg)	CL (30µg)	CEF (30µg)	TE (30µg)	DOX (30µg)	IMP (30µg)	VA (30µg)	RD (5µg)	C (30µg)
28.15 (60)	27.08 (48)	7.08 (146)	9.76 (146)	22.08 (161)	81.79 (56)	-	69.74 (95)	0 (21)	54.85 (225)	1.49 (67)	1.01 (134)	95.62 (146)	50 (12)	25.00 (32)
30 (20)	-	3.48 (23)	20 (23)	18.46 (13)	56.67 (18)	-	-	-	-	-	20 (10)	96.19 (21)	76.92 (13)	0 (12)
-	-	40 (13)	57.15 (14)	-	50 (10)	-	-	-	-	-	16.36 (11)	26 (10)	-	-
14.55 (22)	36 (25)	18.16 (38)	30.40 (136)	71 (25)	93.58 (109)	91.43 (105)	7.69 (13)	49.05 (116)	83.74 (123)	-	-	79.17 (12)	-	16.67 (24)
37.24 (29)	0 (25)	3.67 (49)	27.33 (30)	60.43 (44)	61.71 (44)	60 (15)	66.67 (15)	41.5 (10)	60 (15)	40 (25)	-	73.45 (29)	75.00 (20)	30.55 (36)

NEO; Gentamicin = CN; Ciprofloxacin = CIP;

Nalidixic Acid = NA; Erythromycin = ERY; Azithromycin = AZM; Cephalexine = CL; Ceftriaxone = CEF; Tetracycline = TE; Doxycycline = DOX;

Imipenem = IMP; Vancomycin = VA; Rifampicin = RD; Chloramphenicol = C.

[a] = Weighted mean resistance (%)

[b] = values in parenthesis represent the number of isolates

Hyphen (-) represents number of isolates less than 10 (ten), hence not included.

Location				
Dhaka	11	55	[21–26,32,34–37]	
Chittagong	5	25	[9,27–29,31]	
Mymensingh	2	10	[19,38]	
Gazipur	1	5	[30]	
Dinajpur	1	5	[33]	

		KAN (30µg)	7.43 (142)	14.12 (17)	-	-	33.86 (44)
	Penicillins	P (10µg)	100 (131)	-	-	-	100 (20)
		AMX (10µg)	81.49 (121)	58.75 (16)	52.31 (13)	89.06 (123)	83.30 (44)
		AMP (10µg)	93.14[a] (78)[b]	41.42 (14)	-	97.69 (108)	76.40 (25)
Name of Bacteria			*Eshcherichia coli*	*Klebsiella* spp.	*Vibrio* spp.	*Salmonella* spp.	*Pseudomonas* spp.

4. DISCUSSION

Our study revealed high resistance of the selected bacteria to a considerable number of antibiotics especially against Ampicillin, Amoxicillin and Penicillin whereas relatively lower resistance was detected towards Ciprofloxacin, Gentamicin and Imipenem. Several studies carried out in different parts of the world showed a result that complies with our present findings. A study at Tumkur, India found a significant number of ampicillin resistant isolates of *Escherichia coli*, *Salmonella* spp. and *Vibrio* spp. from street vended foods [39].The corresponding result was also observed in Delhi where *Escherichia coli*, *Salmonella* spp., *Vibrio* spp. isolated from different fruit juices exhibited a relatively higher resistance to ampicillin[40]. Apart from the Indian subcontinent, the outcome of this review is upheld by different studies conducted in Africa as well. A study held in Akure Metropolis, Nigeria revealed the high resistance capability of *Escherichia coli*, *Salmonella* spp., *Pseudomonas* spp. and *Vibrio* spp. against amoxicillin, all of these bacteria were also highly resistant to tetracycline except for the latter one [41]. Another study conducted in Ethiopia revealed quite a similar result where isolates of *Escherichia coli* found in street foods were comparatively less resistant to ceftriaxone, ciprofloxacin, gentamycin, kanamycincompared to ampicillin[42]. Tadesse et al. (2019) reported

Salmonella spp. isolated from street foods of Eastern Ethiopia were detected to be predominant over ampicillin, amoxicillin and tetracycline[43].

In developing countries like Bangladesh, people can obtain most of the antibiotics over the counter at a cheaper price without any medical prescription [7]. Overuse and misuse of these antibiotics are linked to the emergence of resistant bacteria [44]. For example, amoxicillin is frequently used among low income people as it is relatively cheaper which might be a reason why bacteria are highly resistant to it [45]. Bacteria also get exposed to antibiotics from the environment as most of the antibiotics used in human and food producing animals ultimately make their way to the environment [9]. Moreover, most pharmaceutical companies do not treat their wastes properly before disposing of them in the ponds, rivers and other water systems [46]. Repeated low doseexposure to antibiotics triggers bacteria to start developing resistance mechanisms and hence its presence in the environment plays a crucial role in the emergence of resistant bacteria [9,46].In addition to the acquired type of resistance in bacteria, they can be intrinsically resistant to many antibiotics and have the potential to transfer resistance elements residing within their genomes to other pathogenic bacteria[15]

Resistant bacteria enter the food chain through animal based foods [47]. *Escherichia coli*, *Salmonella* spp. isolated from some commonly used raw animal food like meat, chicken egg and milk were found resistant to most of the antibiotics [8,48,49]. Therefore, it can be a reason for the presence of antibiotic resistant bacteria in street foods. Also, cross contamination can occur through water sources as street vendors frequently use municipal water for preparing fruit juices and for washing purposes [40]. *Escherichia coli* isolated from tap water collected from Dhaka, Jamalpur, Tangail, Netrokona, Kishoreganj showed resistance against tetracycline, erythromycin, amoxicillin, streptomycin and some other antibiotics [50,51].The unhygienic condition of the

vendors and the food preparing places are also accountable for cross contamination. Hassan et al. (2017) reported *Escherichia coli* and *Klebsiella* spp. isolated from hand-rinsed water of street vendors were found resistant against amoxicillin, ciprofloxacin, gentamycin and azithromycin [45].

Given the fact that most of the studies included in this review were concentrated around Dhaka, there is a likelihood of selection bias and this review might not portray the complete scenario of Bangladesh. Moreover, due to the insufficiency of the studies available, authors were compelled to include even the studies that performed AST on a single isolate. However, the weighted mean was calculated only if the isolate number was 10 or more, combining all the studies. While extracting the percentage values of resistance from a graph, some data had to be excluded for not being sufficiently clear. The authors combined data acquired from all the selected studies even though half the studies did not mention their testing standard. However, since the other half followed the CLSI guidelines and all the studies employed the disc diffusion method, the extent of variation should be negligible.

5. CONCLUSION

More studies should be carried out in different parts of Bangladesh as data was only available for five districts out of the sixty-four districts. Nevertheless, despite the data gaps and otherlimitations, it is apparent that the prevalence of antibiotic resistant bacteria is considerably high in the street-vended foods of Bangladesh. Therefore, improved regulatory frameworks need to be established and the surveillance system should be strengthened to control the misuse of antibiotics. Alongside, public awareness programs should be held. The street food vending needs to be taken under licensing system and only the qualified ones, having been trained on basic food safety and hygiene, should be provided with a license. If adequate actions to combat antibiotic

resistance is not considered immediately, it will have a devastating impact on the public health in the coming decades.

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