A Study of Consumer Perception of Antibiotic Resistance and Antibiotic Use in Ireland

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A Study of Consumer Perception of Antibiotic Resistance and Antibiotic Use in Ireland

By

Andreea Todea

Submitted to the Dublin Institute of Technology in partial fulfillment of the requirements of degree of Master of Science (Food Safety Management)

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COLLEGE OF SCIENCES AND HEALTH
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Abstract

The purpose of this study was to assess the knowledge of Irish consumers regarding antibiotic use in Ireland. Data was obtained on antibiotic use, frequency, associated source and general awareness regarding antibiotics and antibiotic resistance.

A cross-sectional survey was designed to analyse consumer’s perception and knowledge of antibiotic and antibiotic resistance. A total of 763 completed questionnaires were collected. The questionnaire was targeted for general public, based in Ireland.

Fifty-seven percent of respondents are trying to completely avoid antibiotics, unless absolutely necessary. Half of respondents (50%) took antibiotics in the last 12 months. The majority of respondents obtained antibiotics through a valid medical prescription. A prevalence of 6% of self-medication with antibiotic mainly leftovers from previous course was reported. Almost 80% of the respondents discontinue the antibiotic treatment when all antibiotics have been taken as directed. Gaps in population understanding of antibiotics were observed. Only 47% of the respondents knew that antibiotics were not effective against viruses. Eighty-two percent of respondents understood that unnecessary use of antibiotics make them ineffective. Almost sixteen percent had never heard of the term Antibiotic Resistance. Almost all the respondents stated that the availability of public awareness campaigns is poor. The majority of respondents (70%), noted that they would trust social media to inform them about antibiotic resistance.

It is important to note that there are some notable socio-demographic differences in relation to the frequency of antibiotic intake. Furthermore, this study suggests that an increase in educational degrees is correlated with the level of awareness. Although the study shows a certain level of understanding of the antimicrobial resistance problem, there still is a lack of knowledge, mostly reported by consumers with a lower level of education.
DECLARATION

I hereby certify that this material, which I now submit in part fulfillment of the requirement for the award of MSc in Food Safety Management, is entirely my own work and has not been taken from the work of others save and to the extent such work has been cited and acknowledge within the text of my work.

This thesis was prepared according to the guidelines for dissertation production in the MSc Food Safety Management and has not been submitted in whole or in part to any other Institute or University.

The work reported on in this thesis conforms to the principles and requirements of the Institute’s guidelines for ethics in research.

The Institute has permission to keep, to lend or to copy this thesis in whole or in part, on condition that any such use of material be duly acknowledge.

Signed: __________________________

Candidate

Ms. Andreea Todea

Date: __________________________
ACKNOWLEDGEMENTS:

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Secondly, I would like to express my gratitude to my supervisor Dr. Ciara Walsh, for her unwavering support, guidance and insight throughout this research project.

And finally, I would like to thank my partner Michael, my close friend Sonia and my work colleagues. You have all encouraged and believed in me. You have all helped me to focus on what has been hugely rewarding and enriching process.
ABBREVIATIONS

* AMR: Antimicrobial Resistance
* DNA: Deoxyribonucleic acid
* DG-SANTE: Directorate-General for Health and Food Safety
* EAAD: European Antibiotic Awareness Day
* EARS-NET: European Antimicrobial Resistance Surveillance Network
* ECDC: European Centre for Disease Prevention and Control
* EFSA: European Food Safety Authority
* EMA: European Medicines Agency
* EU: European Union
* FSAI: Food Safety Authority Ireland
* FAO: Food and Agriculture Organization
* GP: General Practitioner
* HACCP: Hazard Analysis and Critical Control Points
* HRPA: Health Products Regulatory Authority
* MRSA: Methicillin-resistant Staphylococcus Aureus
* NGO: Non-Governmental Organization
* PBP: Penicillin-binding Protein
* PCU: Population Correction Unit
* STEC: Shiga Toxin-producing Escherichia coli
* US: United States
* VISA: Vancomycin Intermediate Staphylococcus aureus
* VPA: Veterinary Product Authorization
* VRSA: Vancomycin-resistant Staphylococcus Aureus
* WHO: World Health Organization
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Chapter 1: Literature Review

1.1. History

Infections are very common and are responsible for a large number of diseases affecting human health. Infectious diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites or fungi; the diseases can be spread, directly or indirectly, from one person to another. Zoonotic diseases are infectious diseases of animals that can cause disease when transmitted to humans. (Anon., n.d.)

Infections caused by bacteria can be prevented, managed and treated through antibacterial group of compounds known as antibiotics.

Sir Alexander Fleming, a Scottish biologist laid the foundations for modern antibiotics with his discoveries of enzyme lysozyme in (1923) and the antibiotic substance penicillin in 1928.

It was in 1928 when Sir Alexander Fleming observed interesting zones of clearing (inhibition) on a bacterial agar plate around a common fungus. This fungus was identified as Penicillium notatum which had an antibacterial effect on a strain of Staphylococcus. The active substance was effective even when diluted up to 100 times.

Later he would say,

“I certainly didn’t plan to revolutionize all medicine by discovering the world’s first antibiotic, or bacteria killer. But I suppose that was exactly what I did”. (Tan, 2015)

Penicillin made a difference during the first half of the 20th century. The first patient was successfully treated for streptococcal septicemia in the United States in 1942. However, supply was limited and demand was high in the early days of penicillin.

Penicillin helped reduce the number of deaths and amputations of troops during World War II. According to records, there were only 400 million units of penicillin available during the first five months of 1943; by the time World War II ended, U.S. companies were making 650 billion units a month. (Kalvaitis, 2008)
In a 1945 interview with The New York Times, Alexander Fleming, who won a Nobel Prize that year for his discovery of penicillin, warned that misuse of the drug could result in selection for resistant bacteria. True to this prediction, resistance began to emerge within 10 years of the wide scale introduction of penicillin. Indeed, although antibiotics have transformed the medical response to bacterial illness and rendered easily treatable many formerly deadly infections, the mishandling and misprescription of these drugs have transformed the bacterial population such that many antibiotics have partially or entirely lost their efficacy. (Rosenblatt-Farrell, 2009)

The emerging problem of antibiotic resistance has become widely known because of the emergence of methicillin-resistant *Staphylococcus Aureus* (MRSA), an increasingly common bacterial agent with major consequences, identified in the UK in 1962 and in the US in 1968. (Ventola, 2015)

Antimicrobial resistance is reported to affect multiple sectors, especially human health, animal health and agriculture. It requires a collaborative global approach across sectors to detect, prevent, and respond to these threats when they occur. (Anon., 2018)

Over a course of studies, it was discovered that inappropriate use of antimicrobial drugs is closely related to the knowledge, attitudes and behavior of the population. Healthcare professional’s behavior towards prescribing antibiotic is also a contributing factor. Improvement of the rational use of antibiotics is encouraged by the World Health Organization through prescription-only use of antibiotics and through educational measures. (Topor, 2017)

As studies show that the overuse and misuse of antibiotics is closely related to attitudes and behavior of the population, as well as the antibiotic prescribing behavior of the healthcare professionals, this study will evaluate consumer perception towards the use of antibiotic and investigate the level of awareness regarding antimicrobial resistance.
# 1.2 Classification of Antibiotics

<table>
<thead>
<tr>
<th>Mechanism of action</th>
<th>Antibiotic class</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhibition of cell wall synthesis</td>
<td>Penicillin</td>
<td>Penicillin G, methicillin, ampicillin</td>
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<tr>
<td>Major groups (beta-lactams)</td>
<td>Cephalosporins</td>
<td>Cephalexin, cefacor, ceftriaxone</td>
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<td></td>
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<td>Macrolides</td>
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<td></td>
<td>Lincosamides</td>
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<td></td>
<td>Phenicols</td>
<td>Chloramphenicol</td>
</tr>
<tr>
<td>Inhibition of DNA synthesis</td>
<td>Quinolones</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Generation: Flumequine, Nalidixic Acid, Oxolinic Acid, Pipermidic Acid</td>
</tr>
<tr>
<td>Major groups topoisomerase inhibitors (Floroquinolones)</td>
<td></td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; Generation: Ciprofloxacin, Ofloxacin, Norfloxacin, Perfloxacin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3&lt;sup&gt;rd&lt;/sup&gt; Generation: Levofloxacin, Sparfloxacin</td>
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<td></td>
<td></td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Generation: Moxifloxacin, Gatifloxacin, Difloxacin, Enrofloxacin, Markofloxacin</td>
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<tr>
<td>Inhibition of RNA synthesis</td>
<td>Rifamycins</td>
<td>Rifampicin</td>
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<td>Folic Acid synthesis inhibitor</td>
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<td>Membrane disorganizing agent</td>
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<tr>
<td>Other mechanisms</td>
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<td>Metronidazole, secnidazole, tinidazole</td>
</tr>
</tbody>
</table>

Table 1. Classification of antibiotics (Oyindamola, 2017)
1.2.1 Beta-lactams

![Chemical structure of a beta-lactam ring](image)

Figure 1. Chemical structure of a beta-lactam ring (Tidwell, 2008)

Members of this class of antibiotics contain a 3-carbon and 1-nitrogen ring that is highly reactive. They interfere with proteins essential for synthesis of bacterial cell wall, and in the process either kills or inhibits their growth. Certain bacterial enzymes termed penicillin-binding protein (PBP) are responsible for cross linking peptide units during synthesis of peptidoglycan. Members of beta-lactam antibiotics are able to bind themselves to these PBP enzymes, and in the process, they interfere with the synthesis of peptidoglycan resulting in lysis and cell death. The most prominent representatives of the beta-lactam class include Penicillins, Cephalosporines, Monobactams and Carbapenems. (Etebu et al., 2016)

1.2.2 Penicillins

Penicillins are involved in a class of diverse group of compounds, most of which end in the suffix –cillin. They are beta-lactams compounds containing a nucleus of 6-aminopenicillanic acid (lactam plus thiazolidine) ring and other ring side chains. (Etebu et al., 2016)

Certain bacteria are able to counter the activity of antibiotics by encoding enzymes. Antibiotics such as ampicillin, carbenicillin and amoxicillin have been developed semi-synthetically with different side-chains. These side chains confer on the antibiotics the ability to evade the degradative capacity of certain enzymes produces by certain bacterial strains as well as facilitating the movement of antibiotics across the outer membrane of bacterial cell walls. This double-pronged capacity increases their spectrum of activity against Gram-negative bacteria. Some penicillins, such as Augmentin are produced in combination with a non-antibiotic compound that are able to inhibit the activity of bacterial penicillinase enzyme. Therefore,
the combination between an antibiotic and a non-antibiotic compound can prolong the antibacterial activity. (Poirel et al., 2005)

1.2.3 Cephalosporin
Members of this group of antibiotics are similar to penicillin in their structure and mode of action. They form part of the most commonly prescribed antibiotics. (Scholar, 2007) Cephalosporins contain 7-aminocephalosporanic acid nucleus and side-chain containing 3, 6-dihydr-2 H-1, 3-thiazane rings. Cephalosporins are used in the treatment of bacterial infections and diseases arising from Penicillinase-producing, Methicillin-susceptible Staphylococci and Streptococci, *Proteus mirabilis*, some *Escherichia coli*, *Klebsiella pneumonia*, *Haemophilus influenza*, *Enterobacter aerogenes* and some *Neisseria*. (Healy, 2008)

They are subdivided into generations 1st to 5th:
- First generation cephalosporins have the highest activity against gram-positive organisms and the lowest against gram-negative.
- Second generation cephalosporins are more active against gram-negative bacteria, with less activity against gram-positive.
- Third generation cephalosporins have a greater spectrum against gram-negative bacteria and are more resistant to gram-negative B-lactamase enzymes than first and second generation cephalosporins.
- Fourth generation has an improved gram-positive spectrum while retaining the expanded gram-negative activity of the third-generation compounds. (Watson and Bonomo, 2017)
- Ceftaroline fosamil is a novel fifth-generation parental oxyimino cephalosporin with bactericidal activity against MRSA. (Duplessis et al., 2011)

1.2.4 Carbapenems

Carbapenem use has increased as a result of the rising resistance to cephalosporin antibiotics in Enterobacteriaceae. (Livermore, 2012) These compounds occupy a very important place in the fight against bacterial infections. This is because they are able to resist the hydrolytic action of beta-lactamase enzyme. Carbapenems possess the broadest spectrum of activity and greatest potency against Gram-positive and Gram-negative bacteria. (Torres et al., 2014)
1.2.5 Macrolides
The first antibiotic belonging to this class was first discovered and isolated in 1952. Macrolides are characterized by 14-, 15-, 16-membered macrocyclic lactose rings with unusual deoxy sugars L-cladinose and D-desosamine attached. They have a wider spectrum of antibiotic than Penicillins and are often administrated to patients allergic to penicillin. (Moore, 2015). Macrolides tend to build up in the body because the liver is able to recycle it into the bile.

1.2.6 Tetracyclines
Tetracyclines was discovered in 1945 from a soil bacterium of the genus *Streptomyces* by Benjamin Duggar. (Michalova *et al.*, 2004). Members of this class have 4 hydrocarbon rings and they are known by name with the suffix –“cycline”.

*Members of this class of antibiotics are grouped into different generations based on the method of synthesis. Those obtained by biosynthesis are the 1*st* generation which includes: tetracycline, chlortetecycline, oxytetraxycline and demeclocycline. Second generation includes: doxycycline, lymecycline, meclocyline, methacycline, minocycline and rolitetracycline which are derivates of semi-synthesis. Third generation are obtained from total synthesis, such as Tigecycline. (Etebu *et al.*, 2016)*

Their target of antimicrobial activity in bacteria is the ribosome.

1.2.7 Quinolones
This class of antibiotic was first discovered as nalidixic acid by scientists involved in search of antimalarial drugs. (Tillotson, 1996) Quinolones were derived from quinine. (MacGowan, 2003)

They are able to interfere with DNA replication and transcription in bacteria. Their structure generally consists of two rings, but recent generations of quinolones possess an added ring structure (fluorine molecule at C6 created the “fluoroquinolones”) which enables them to extend their spectrum of antimicrobial activity to some bacteria, particularly anaerobic bacteria. (Tillotson, 1996)

1.2.8 Aminoglycosides
The first drug to be discovered among members of this class was streptomycin, first isolated in 1943. (Kalra, 2012). Streptomycin has been greatly used against *Mycobacterium tuberculosis*, the causal agent of tuberculosis among humans. The aminoglycosides are compounds of usually 3-amino sugars connected by glycosidic bonds.
Aminoglycosides have a broad spectrum of antibacterial activity and are effective against aerobic Gram-negative rods and certain Gram-positive bacteria. Streptomycin was found to be highly toxic (Toxnet, 2017), therefore the need of introducing new members of aminoglycosides such as Gentamicin, neomycin, tobramycin and amikacin. Gentamicin is less toxic and is widely used for infections caused by Gram-negative rods (Escherichia, Pseudomonas, Shigella and Salmonella. (Etebu et al., 2016)

1.2.9 Sulphonamides
Sulphonamides are reported as the first group of antibiotics used in therapeutic medicine, as they still play a very important role in medicine and veterinary practice. Sulphonamides inhibit both Gram-negative and Gram-positive bacteria such as Nocardia, E. coli, Klebsiella, Salmonella, Shigella, Enterobacter, Chlamydia trachomatis and some Protozoa and are widely used in the treatment of various infections including tonsillitis, septicemia, meningococcal meningitis and urinary tract infections. (Greenwood, 2010)

1.2.10 Glycopeptides
A Glycopeptide antibiotic is composed of glycosylated cyclic or polycyclic non-ribosomal peptides. Vancomycin is among the most important glycopeptides, although teicoplanin is also available. Glycopeptide antibiotics act primarily by inhibiting the cell wall synthesis of bacteria. Vancomycin and teicoplanin have antimicrobial activity against almost all types of Gram-positive organism including MRSA. Vancomycin is also indicated for treating pseudomembranous colitis cause by Clostridium difficile, against which a limited number of antibiotic are effective. (Kuriyama, 2014)

1.2.11 Oxazolidinones
Oxazolidinones are a new group of antibiotics. These synthetic drugs are active against a large spectrum of Gram-positive bacteria, including methicillin- and vancomycin-resistant staphylococci vancomycin-resistant enterococci, penicillin-resistant pneumococci and anaerobes. Rare development of oxazolidinone resistance cases were reported. (Bozdogan et al, 2004)
Linezolid is used for treatment of respiratory tract and skin infections cause by Gram-positive bacteria pathogens. (Moellering, 2003)
1.3 Antimicrobial Resistance

1.3.1 Definition

Antibiotic resistance occurs when bacteria evolve to evade the effect of antibiotics through multiple different mechanisms. Certain bacteria are able to neutralize an antibiotic by altering its component to render it ineffective. Others might be able to export the antibiotics out of the bacteria, and some can modify their outer structure and receptors so that antibiotics cannot attach to them. These mechanisms might lead to bacteria surviving the use of specific antibiotics and developing resistance that can be passed to other bacteria as they multiply. (Habboush et al, 2018)

The crisis of antimicrobial resistance (AMR) is one of the most serious issues facing the world today. World Health Organization (WHO) published its first Global Report on Antimicrobial Resistance and concluded that, without intervention, we are heading for a post-antibiotic era, where minor infections and small injuries will once again be fatal. According to economist Lord O’Neil who published a report on the impact of AMR, if nothing is done, antibiotic resistance-related deaths would increase from 700,000 annually to 10 million annually by 2050, overtaking cancer as the main cause of mortality. (Venter et al., 2017)

1.3.2 Hospital-acquired infections

The most widespread hospital-acquired infection, responsible for nearly 20,000 in-hospital deaths every year in the USA alone, namely methicillin-resistant *Staphylococcus aureus* (MRSA). In Europe, the percentage of *S.aureus* isolates reported as MRSA is not stabilizing and decreasing in most European countries. However, MRSA remains a public health priority as the percentage of MRSA is still above 25% in seven of 29 reporting countries, mainly in Southern and Eastern Europe. (ECDC, 2015)

1.3.3 Methicillin-resistant *S.aureus*

Same year that Alexander Fleming, Howard Florey and Ernst Chain received their Nobel Prize for the discovery and development of penicillin, the first strains of *S.aureus* resistant
to penicillin started to emerge. Resistance toward penicillin necessitated the development of methicillin, however just after 2 years of its introduction, resistance to methicillin was reported. MRSA strains are highly resistant against most β-lactams and many other classes of antibiotics. Vancomycin is the drug of choice for the treatment of infections caused by methicillin-resistant staphylococci. (Venter et al., 2017)

1.3.4 Vancomycin intermediate \textit{S.aureus} and Vancomycin-resistant \textit{S.aureus}

The National Committee for Clinical Laboratory Standards (NCCLS) defines staphylococci requiring concentrations of vancomycin of \( \leq 4 \mu\text{g/mL} \) for growth inhibitors as “susceptible”, those requiring concentrations of 8-16 \( \mu\text{g/mL} \) for inhibition as “intermediate” and those requiring concentrations of \( \geq 32 \mu\text{g} \) as “resistant”. (Weinstein et al., 2001). A strain of \textit{S.aureus} with reduced vancomycin susceptibility (VISA) was first reported in 1997 in Japan. VRSA strains have also emerged but only a few cases were reported, and it does not represent an urgent public health threat. Currently, the advanced generation of cephalosporin ceftaroline, the lipopeptide daptomycin, vancomycin analogues telavancin and oxazolidinones linezolid and tedizolid can still be used against MRSA. (Venter et al., 2017)

1.3.5 Resistance through the use of antibiotics in veterinary science and agriculture

\textbf{Colistin-resistance}

Colistin-resistant \textit{Acinetobacter spp.} was first reported in the Czech Republic in 1999. (Cai et al., 2012).

Colistin is characterized by remarkable antimicrobial activity against Gram-negative organism such as multidrug-resistant \textit{Pseudomonas aeruginosa}, \textit{Acinetobacter baumannii}, and \textit{Klebsiella pneumoniae} as being considered the last line of defense caused by these organisms. It has been extensively used orally since the 1960s in food animals and particularly in swine for the control of Enterobacteriaceae infections caused by \textit{Escherichia coli}. (Rhouma et al., 2016)

Since its introduction on the market in the 60s, colistin was used in pig production in several countries with different purposes: therapeutically, prophylactically and even for growth promotion. (Katsunuma et al., 2007).

The discovery of horizontal mechanism of colistin resistance raised alarm bells about the impact of colistin use on colistin resistance spread in animal production, especially in
swine. In fact, the link between pigs and humans in terms of colistin resistant *E.coli* strain transfer following direct contact has recently been confirmed. (Olaitan *et al*., 2015)

Colistin is not used in agriculture in the United States but was the fifth most commonly used antimicrobial on farms in the European Union in 2011. (Catry *et al*., 2015)

Since China used a vast amount of colistin in agriculture, it is likely selective pressure in the veterinary environment there led to *E.coli* acquiring mcr-1 gene. Recent news report that China has banned the use of this drug in animal feed in 2016, following the discovery of MCR-1. (CIDRAP, 2017)

### 1.3.6 Resistance from farm to fork

Several outbreaks of infectious disease caused by multidrug-resistant organisms, acquired through food sources, have brought the issue of the use of antibiotics in agriculture firmly into public attention.

In 2014, a multistate outbreak of multidrug-resistant *Salmonella heidelberg*, in the USA was linked to consumption of chicken meat from one supplier. Prophylactic use of antimicrobials is huge, currently estimated at a global annual of 148 mg of antibiotic per kg of animal produced. (Van Boeckel *et al*., 2015).

A recent outbreak of multidrug-resistant *Salmonella* linked to raw chicken products was reported this year with 92 people infected with the outbreak strain of *Salmonella Infantis*.(CDC, 2018)

Antibiotic-resistant bacteria may reach humans indirectly along the food chain through consumption of contaminated food or food derived products and following direct contact with colonized/infected animals or biological substances such as blood, urine, faeces, saliva and semen among others. Given the direct interaction of humans with the animal-ecosystem interface, it is essential to prevent the zoonotic transmission of antibiotic-resistant bacteria from food animals-associated reservoirs to humans. (Founnou *et al*., 2016)
Figure 2. Developing Antibiotic Resistance: A Timeline of Key Events (Ventola, 2015)
1.4 Mechanisms of Antimicrobial Resistance

Bacteria may manifest resistance to antibacterial drug through a variety of mechanisms discussed below.

1.4.1 Intrinsic Resistance

Intrinsic resistance is due to the physiological properties of a micro-organism, which are generally chromosomally encoded. (Walsh et al., 2008) Some microbes are naturally able to resist the antimicrobial activities of antibiotics due to their structure of functional processes. In one example, Enterococci species are intrinsically resistant to cephalosporins because this drug binds to a peptidoglycan binding protein (PBP) that these bacteria do not have. (Wolf, 2017)

Another example, Klebsiella spp and Enterobacter spp are intrinsically resistant to ampicillin based on their production of beta-lactamases that destroy the drug before it can reach its PBP targets. (Wolf, 2017) Gram-negative bacteria generally have higher levels of resistance than Gram-positive bacteria. More specifically, Gram-Negative bacteria are innately resistant to penicillin G by virtue of their double membrane structure, which prevents the antibiotic from accessing the cell wall. Innate resistance is not considered a clinical problem because antibiotics were never intended for use against intrinsically resistant bacteria. (Walsh et al., 2008)

1.4.2 Extrinsic Resistance

Extrinsic resistance or acquired resistance occurs when a particular microorganism obtains the ability to resist the activity of an antimicrobial agent to which it was previously susceptible. This can result from the mutation of genes involved in normal physiological processes and cellular structures, from the acquisition of foreign resistance genes or form a combination of these two mechanisms.

Unlike intrinsic resistance, traits associated with acquired resistance are found only in some strains or subpopulations of each particular bacterial species. Acquired resistance results from successful gene change and/or exchange that may involve mutation or horizontal gene transfer via transformation, transduction or conjugation. (Tenover, 2006)
1.5 One Health Approach

One Health recognizes that the health of humans, animals and ecosystems are interconnected. It involves applying a coordinated, collaborative, multidisciplinary and cross-sectorial approach to address potential or existing risks that originate at the animal-human-ecosystems interface. (CDC, 2018)

To improve the effectiveness of the One Health approach, there is a need to establish a better sectorial balance among existing groups and networks, especially between veterinarians and physicians, and to increase the participation of environmental and wildlife health practitioners, as well as social scientists and development actors.

In less than four years, One Health has gained significant momentum. The approach has been formally endorsed by the European Commission, the US Department of State, Centre of Disease and Control (CDC), WHO, NGOs, FAO, etc.

The One Health concept is founded on an awareness of the major opportunities that exist to protect public health through policies aimed at preventing and controlling pathogens within animal populations, and the interface between humans, animal and the environment.

The concept provides a better understanding of:
• mechanism of human disorders
• improve control and prevention of infectious agents
• reduce economical losses due to diseases of livestock and crops
• support the international efforts in campaign for sustainable environment.

Antimicrobial resistance is a major challenge to global health. It has been estimated that if no action is taken against AMR, it will be the leading cause of death with 10 million victims per year by 2050.

Therefore, countries all over the world have been developing approaches in line with One Health principles to tackle AMR. Following a report published in 2016, Review on Antimicrobial Resistance, by Jim O’Neil, there are 10 different perspective on how to tackle AMR (O’Neil, 2016):
1. A global public awareness campaign
2. Improve sanitation and prevent the spread of infections
3. Reduce unnecessary use of antimicrobial in agriculture into the environment
4. Improve global surveillance of drug resistance and microbial consumption
5. Promote new and rapid diagnostics
6. Promote development and use of vaccines and alternative
7. Improve the number and recognition of people working with infectious diseases
8. A global innovation fund for early stage and non-commercial
9. Better incentives to promote investment for new drugs and improving existing ones
10. Build a global coalition for real action

Compliance with Good Manufacturing Practices should be encouraged, as well as transparency in global supply chains and ethical procurement policies. Antibiotic residues in ground and surface water should be monitored to ensure to be compliance with the European Commission’s strategic approach. International trade and increased mobility of people and animals are factors that require consideration, e.g. through imports of meat and other food products from countries that do not necessarily follow the same high standards as the EU, as drug resistant bacteria can easily cross continents. (EC, 2017).

The EU scientific agencies (ECDC, EFSA, and EMA) have delivered on the Action Plan’s commitment to developing a set of key outcome indicators to assess progress on reduction of AMR and antimicrobial consumption. This provides an opportunity towards targets and goals supporting a reduction in AMR. The existing data/use, germ resistance levels, the number of healthcare associated infections or communicable diseases and the AMR burden should serve through the new Action Plan as a benchmark for national reduction target. In the veterinary field, a well-established system of surveillance and monitoring of sales of antibiotics in food producing animals has been implemented (EC, 2017). From a One Health Perspective, there are major data gaps regarding European surveillance and monitoring in all sectors of AMR: human medicine, agriculture and environment.

European Antibiotic Awareness Day (EAAD) takes place every year on 18 November to raise awareness about the threat to public health from antibiotic resistance and the importance of prudent use of antibiotics.
The latest data confirms that across the European Union the number of patients infected by resistant bacteria is increasing and that resistance is a major threat to public health. (EFSA, 2018)

Prudent use of antibiotics can help stop resistant bacteria from developing and keep antibiotics effective for future generations.

1.6 Antibiotic resistance in the European Union

After a study conducted and published by ECDC - “Summary of the latest data on antibiotic resistance in the European Union” the conclusions show that antibiotic resistance is a serious threat to public health in Europe, leading to increased healthcare costs, prolonged hospital stays, treatment failures and also death. The data included in the study was collected by the European Antimicrobial Resistance Surveillance Network (EARS-Net), which is coordinated by ECDC. EARS-Net collects data on invasive bacterial isolates from 30 EU/EEA countries.

EARS-Net performs surveillance of antimicrobial susceptibility of seven bacterial pathogens commonly causing infections in humans: *Escherichia Coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Acinetobacter pneumoniae, Staphylococcus aureus, Enterococcus faecalis* and *Enterococcus faecium*. The latest summary from November 2016 shows that Resistance percentages were generally higher in southern and south-eastern Europe than in northern Europe.

For *Klebsiella pneumoniae*, combined resistance to three or more of the antimicrobial groups under surveillance was the most common resistance phenotype. Resistance to fluoroquinolones, third-generation cephalosporins and aminoglycosides, as well as combined resistance to all three groups, increased significantly at EU level, from 17.7% in 2012 to 18.6% in 2015, meaning that for patients who are infected with these multi-drug resistant bacteria, only a few therapeutic options remain available. Among there are carbapenems, a last-line group of antibiotics.

However, carbapenem resistance percentages remained at low levels for most countries in 2015, resistance to carbapenems at EU level significantly increased in the past years, from a population weighted mean percentage of 6.2% in 2012 to 8.1% in 2015. A vast majority of the carbapenem-resistant isolates had additional resistance to fluoroquinolones, third-generation cephalosporins and aminoglycosides.
Ireland had a huge increase in combined resistance to fluoroquinolones, third generation cephalosporins and aminoglycosides, results taken from 312 isolates, in 2012 - 3.4%, in 2013 -7.9% but then in 2014 slowly drops to 7.4% and in 2015 - 7.2%.

Antibiotic resistance in *E. coli* requires close attention as the percentages of isolates resistant to commonly used antibiotic continue to increase throughout Europe. Of particular concern is the increase in resistance to third-generation cephalosporins which increased significantly at EU level from 11.9% in 2012 to 13.1% in 2015 and combined resistance to third generation cephalosporins, fluoroquinolones and aminoglycosides which increased significantly at EU level from 4.9% in 2012 to 5.3% in 2015. Again, the study of Ireland, on 2288 invasive isolates tested the levels raised from 9.2% in 2012 to 11.4 in 2015 in regard to the resistance to third generation cephalosporins.

*Acinetobacter* species mainly cause healthcare-associated infections, such as pneumonia and bloodstream infections, and often result in hospital outbreaks if appropriate prevention and control measures are not implemented. Antibiotic resistance in *Acinetobacter spp.* showed large variations across Europe, with generally high resistance percentages reported from the Baltic countries and southern and south-eastern Europe. Combined resistance to fluoroquinolones, aminoglycosides and carbapenems was the most frequently reported resistance in 2015.

Methicillin-resistant *Staphylococcus aureus* (MRSA) as mentioned previous is one of the most frequent causes of antibiotic resistance healthcare-associated infections worldwide. The EU population weighted mean percentage decreased significantly from 18.8% in 2012 to 16.8% in 2015. However, despite de positive outcome, MRSA remains a public health priority in Europe as 8 out of thirty countries reported MRSA percentage above 25%. Comprehensive MRSA strategies targeting all healthcare sectors remain essential for the reduction of the MRSA spread in Europe.

*Enterococcus faecium* and *Enterococcus faecalis* can cause a variety of infections, including endocarditis, bloodstream infections, and urinary tract infections. Vancomycin-resistant enterococci (VRE) mainly cause healthcare-associated infections and often result in hospital outbreaks if appropriate prevention and control measures are not implemented.

Vancomycin resistance was more common in *E. faecium* than *E faecalis* and high percentages of vancomycin resistance was reported from countries in Eastern Europe. A
significant increase was observed in 12 out of 26 countries, reporting more than 20 isolates per year. (ECDC, 2016)

1.7 Antibiotics use in Agriculture

1.7.1 Treatment of farm animals
The prevalence of pathogens on farms depends on many factors, such as type of husbandry, the environmental pressure on the farm, and the standard of the farm. The most commonly used antimicrobial drugs in animals reared for food are from the five major classes: β-lactams, tetracyclines, aminoglycosides, macrolides and sulphonamides. The discovery of third generation fluoroquinolones with a broader spectrum of activity has led to interest in their use in animals. (Johnston, 1998)

1.7.2. Prophylaxis
Prophylaxis or strategic treatment is usually to contain the spread of infection and prevent illness before the development of clinical signs. It involves treating a herd or group of animals after illness has been diagnosed in one or more animals in the group. Diseases requiring the most extensive use of antimicrobial drugs for treatment or prophylaxis are respiratory and enteric diseases in pigs and cattle and mastitis in dairy cattle. (Johnston, 1998)

1.7.3 Performance enhancement
The performance enhancement properties of antimicrobial drugs are used to improve the productivity of healthy animals by improving growth rate, feed conversion, or yield. The growth promoting properties of these agents in farm animals were discovered in the late 1940s. In Europe, this activity has been banned since January 1, 2006. (EC, 2017)

According to a survey on the most common antibiotics used to treat animals in Europe (2014), completed by 3000 veterinarians, shows differences in preferred antibiotics according to species and for the same indication in different countries. This may be due to differences in availability, different production systems or differences in veterinary prescribing behavior.

Many older antibiotics (penicillins, tetracyclines, potentiated sulphonamides etc.) are still the ones that veterinarians most frequently say they would use to treat the main food producing species. The most important factors overall influencing a veterinarian to prescribe a certain antibiotic were sensitivity test results, their own experience, a
consideration of the risks of antibiotic resistance development and ease for administration. (Briyne et al., 2014).

1.7.4. Cattle
The predominant reason for antibiotic administration was for the control of mastitis in dairy cows, where antibiotic treatment may be given for clinical or subclinical mastitis. Third and fourth generation cephalosporins are cited to be the most frequent administered, due to their very short withdrawal period. Data for calves were also available, reporting that diarrhea and respiratory diseases were the most frequent usage for antibiotic administration.

1.7.5. Pigs
The reported predominant use of antibiotics was for respiratory disease (mostly tetracyclines and penicillins) and diarrhea (mostly polymyxin and macrolides). A Belgian study reported that the most common antibiotic administrated to pigs was colistin, amoxicillin and doxycycline. (Callens et al., 2012) Some countries introduced a ban or restriction on the use of certain antibiotics in pigs. Denmark restricted the use of quinolones in 2002 and introduced a voluntary ban on use of third and fourth generation cephalosporins in 2010.

1.7.6 Horses
The predominant use of antibiotics was for skin diseases and respiratory conditions. The most frequently antibacterial administrated was penicillins followed by potentiated sulphonamides regarding if the horse is declared as companion animal or for food production. (Briyne et al., 2014)

1.8 Use of veterinary antimicrobial agents

In veterinary medicine, antimicrobials are used both for the treatment of individual animals and also for the medication of group animals, if required.

In Ireland, medication of groups of animals is carried out most commonly in intensively reared farm animals such as pigs, poultry and farmed fish. Antimicrobial may be used for therapy, metaphylaxis or prophylaxis.
EPRUMA (European Platform for Responsible Use of Medicines in Animals) defines therapeutic treatment as the treatment of animals following diagnosis of disease. Metaphylaxis is defined as medication of groups of animals when disease has been diagnosed in some members of the group, with the aim of treating the clinically affected animals, while preventing spread of disease to unaffected or sub-clinically affected animals. Prophylaxis is defined as medication of animals before clinical signs of disease in order to prevent the occurrence of disease. (FSAI, 2015)

1.9 Regulatory Framework

Antimicrobial agents are animal remedies that are administrated by veterinarians and farmers to animals.

The use of antimicrobial agents in food animals in governed by various pieces of European and Irish legislation relating to the production, distribution, supply and administration of medicine to food animals.

At EU level, the primary legislation is set out in Directive 2011/82/EC, and at national level the primary legislation is the Animal Remedies Act No.23 of 1993. The detailed provisions are set out nationally (S.I No. 786 of 2007).

In addition to this medicine framework, other relevant legislative frameworks include those referring to residues, food safety, animal health and animal by-products including, Regulation (EC) No 882/ 2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules is the legal framework for sampling methods and methods of analysis of feed for control purposes.

The regulatory framework around animal remedies is designed around these concepts:

• only medicines of adequate quality, safety and efficacy are administrated to animals
• administration is restricted to circumstances where there is sufficient benefit to recipient animals
• consumers of products derived from the recipient animals are protected from risks to their health related to the products (Walsh, 2010)

The approach to ensuring the safety quality and efficacy is requiring the authorization of all animal remedies by a competent authority, following demonstration of the appropriate characteristics by the pharmaceutical company intent on placing the product on the market.
In Ireland this responsibility rests with the Health Products Regulatory Authority (HPRA). Only products which have been allocated a Veterinary Product Authorization (VPA) may be sold or administrated to animals. (FSAI, 2015)

However, there is an exception, known as the “cascade” in which there is no authorized product to treat a particular illness therefore a veterinary practitioner may use human medicine authorized by HPRA or an animal remedy authorized in another Member state of the EU. In the case of food animals, only substance with a Maximum Residue Limit (MRL) may be used and minimum withdrawal periods apply.

The VPA of each animal remedy categorizes remedies to designate the allowable supply route for that formulation:

- VSO. Veterinary Surgeon-Only. These may only be dispensed and administrated by a veterinary practitioner.
- POM. Prescription Only Medicine. These remedies may only be dispensed according to a prescription by a veterinary surgeon. Their dispensing and administration may be done by non-veterinarians in accordance with the veterinary prescription.
- Pharmacy only (PS) or Licensed Merchant (LM) products may only be dispensed by a pharmacy or by a licensed merchant. (Walsh, 2010)

A key part of the regulatory basis for administering animal remedies to food animals is the management of risks that might arise to consumers through the consumption of the food products harvested from those animals, e.g. meat, milk, eggs or honey. The decline of concentration of the remedy within animal tissues after administration is assessed and a withdrawal period (the minimum duration from administration until harvesting of food from an animal) is established for all remedies authorized for use in food animals.

Distributors, suppliers, prescribers and administrators of animal remedies are required to maintain appropriate records, and the on-farm remedy register should support compliance by farmers in deciding when to allow food products enter the food chain. (FSAI, 2015)

The European Medicines Agency is a decentralized body of the EU. Its main responsibility is the protection and promotion of public and animal health, through the evaluation and supervision of medicines for human and veterinary use. The Agency is responsible for the scientific evaluation of applications for European marketing authorizations for both human and veterinary medicines.
The European Surveillance of Veterinary Antimicrobial Consumption (ESVAC), following a request from European Commission to collect and report data on the use of antimicrobial agents in animals from the Member States.

In the following charts, data from 30 European countries was collected in relation to the use of antimicrobials in 2016.

A population correction unit (PCU) is applied as a proxy for the size of the food-producing animal population (including horses). The main indicator used in the current report to express the sales is milligrams of active ingredient sold per population correction unit — mg/PCU.

1) The sales of veterinary antimicrobial agents, expressed as mg sold per population correction unit (PCU), ranged from 2.9 mg/PCU to 453.4 mg/PCU across the 30 EU countries, mainly for food producing animals, in 2016. (ESVAC, 2018)

<table>
<thead>
<tr>
<th>Country</th>
<th>Sales (tonnes) for food producing animals</th>
<th>PCU</th>
<th>mg/PCU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>44.1</td>
<td>957</td>
<td>46.1</td>
</tr>
<tr>
<td>Belgium</td>
<td>240.4</td>
<td>1.715</td>
<td>140.1</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>61.1</td>
<td>393</td>
<td>155.3</td>
</tr>
<tr>
<td>Croatia</td>
<td>26.6</td>
<td>286</td>
<td>92.9</td>
</tr>
<tr>
<td>Cyprus</td>
<td>46.3</td>
<td>102</td>
<td>453.4</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>43.2</td>
<td>705</td>
<td>61.2</td>
</tr>
<tr>
<td>Denmark</td>
<td>98.7</td>
<td>2.420</td>
<td>40.8</td>
</tr>
<tr>
<td>Estonia</td>
<td>7.2</td>
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<td>64.0</td>
</tr>
<tr>
<td>Finland</td>
<td>9.7</td>
<td>521</td>
<td>18.6</td>
</tr>
<tr>
<td>France</td>
<td>513.9</td>
<td>7.143</td>
<td>71.9</td>
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<td>Germany</td>
<td>779.2</td>
<td>8.734</td>
<td>89.2</td>
</tr>
<tr>
<td>Greece</td>
<td>79.9</td>
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<tr>
<td>Hungary</td>
<td>155.6</td>
<td>832</td>
<td>187.1</td>
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<td>Iceland</td>
<td>0.6</td>
<td>120</td>
<td>4.7</td>
</tr>
<tr>
<td>Country</td>
<td>Sales (tonnes) for food producing animals</td>
<td>PCU</td>
<td>mg/PCU</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------</td>
<td>-----</td>
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</tr>
<tr>
<td>Ireland</td>
<td>102.3</td>
<td>1.963</td>
<td>52.1</td>
</tr>
<tr>
<td>Italy</td>
<td>1,213.2</td>
<td>4.116</td>
<td>294.8</td>
</tr>
<tr>
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<td>5.4</td>
<td>180</td>
<td>29.9</td>
</tr>
<tr>
<td>Lithuania</td>
<td>12.7</td>
<td>338</td>
<td>27.7</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>1.9</td>
<td>55</td>
<td>35.5</td>
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<td>Netherlands</td>
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<td>37.6</td>
<td>806</td>
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</tr>
<tr>
<td>UK</td>
<td>321.7</td>
<td>7.142</td>
<td>45</td>
</tr>
</tbody>
</table>

Table 2. Sales of veterinary antimicrobial agents in 30 European countries in 2016, Eight ESVAC report (ESVAC, 2018)

Variations in sales may be due to the differences between the countries in the proportion of the various food producing animal species, the availability of veterinary antimicrobial products on the market, prices, animal-production systems, the general situation regards to animal disease, vaccination programmes, management and implementation of responsible use campaign. (EMA, 2018)
2) Sales of antimicrobial agents by antimicrobial class as percentage of the total sales for food-producing animals, in mg/PCU, by 30 European countries, in 2016

![Figure 3. Sales of antimicrobial agents by antimicrobial class, by 30 European countries, in 2016 (ESVAC, 2018)](image)

Of the overall sales of antimicrobials in the 30 countries in 2016, the largest amounts, expressed as a proportion of mg/PCU, were accounted for by tetracyclines (32%), penicillins (26%) and sulfonamides (12%). Overall, these three classes accounted for 70% of total sales in the 30 countries.
3) Distribution of sales, in mg/PCU, of the various pharmaceutical form of veterinary antimicrobial agents in food producing animals, by the 30 European countries, in 2016.

Figure 4. Distribution of sales of the various pharmaceutical form of veterinary antimicrobial agents in food producing animals, 2016 (ESVAC, 2018)

Across the 30 countries, the sales (mg/PCU) of pharmaceutical forms for group treatment accounted for 90.1% of the total sales: premixes accounted for 40.8%; oral powders for 11.9%; and oral solutions for 37.4%. The proportion accounted for by pharmaceutical forms for group treatment varied substantially between countries, ranging from 5% to 96%. Of pharmaceutical forms for treatment of individual animals (9.9%), 9.0% of the sales were accounted for by injectable preparations, 0.6% by intramammary preparations and 0.3% by oral pastes, boluses and intrauterine preparations.
4) Estimated PCU (in 1,000 tonnes) of the population of food producing species, by country, in 2016

<table>
<thead>
<tr>
<th>Country</th>
<th>Cattle</th>
<th>Pig</th>
<th>Poultry</th>
<th>Sheep/goats</th>
<th>Fish</th>
<th>Rabbits</th>
<th>Horses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>441</td>
<td>369</td>
<td>80</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>957</td>
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<td>455</td>
<td>882</td>
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<td>47</td>
<td>100</td>
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<td>0.1</td>
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<td>38</td>
<td>47</td>
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<td>642</td>
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<td>47</td>
<td>211</td>
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<td>3,807</td>
<td>1,071</td>
<td>137</td>
<td>19</td>
<td>20</td>
<td>520</td>
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<td>116</td>
<td>128</td>
<td>784</td>
<td>123</td>
<td>0</td>
<td>11</td>
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<td>97</td>
<td>23</td>
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<td>21</td>
<td>832</td>
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<td>6</td>
<td>47</td>
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<td>308</td>
<td>44</td>
<td>0</td>
<td>60</td>
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<tr>
<td>Italy</td>
<td>1,592</td>
<td>847</td>
<td>755</td>
<td>590</td>
<td>171</td>
<td>29</td>
<td>132</td>
<td>4,116</td>
</tr>
</tbody>
</table>
Table 3. Estimated PCU (in 1000 tonnes) of the population of food producing species, by country, in 2016 (ESVAC, 2018)

<table>
<thead>
<tr>
<th>Country</th>
<th>Cattle</th>
<th>Pig</th>
<th>Poultry</th>
<th>Sheep/goats</th>
<th>Fish</th>
<th>Rabbits</th>
<th>Horses</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Latvia</td>
<td>111</td>
<td>37</td>
<td>19</td>
<td>8</td>
<td>0</td>
<td>0.1</td>
<td>4</td>
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<td>Lithuania</td>
<td>192</td>
<td>72</td>
<td>56</td>
<td>12</td>
<td>0</td>
<td>0.1</td>
<td>7</td>
<td>338</td>
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<tr>
<td>Luxembourg</td>
<td>40</td>
<td>12</td>
<td>0.1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1,174</td>
<td>1,685</td>
<td>398</td>
<td>94</td>
<td>62</td>
<td>1</td>
<td>33</td>
<td>3,446</td>
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<tr>
<td>Norway</td>
<td>214</td>
<td>130</td>
<td>68</td>
<td>108</td>
<td>1.326</td>
<td>0</td>
<td>50</td>
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<tr>
<td>Poland</td>
<td>1,547</td>
<td>1,453</td>
<td>1,266</td>
<td>18</td>
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<td>121</td>
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<tr>
<td>Portugal</td>
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<td>220</td>
<td>174</td>
<td>10</td>
<td>6</td>
<td>18</td>
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<tr>
<td>Romania</td>
<td>929</td>
<td>553</td>
<td>453</td>
<td>1,001</td>
<td>7</td>
<td>0.002</td>
<td>173</td>
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<tr>
<td>Slovakia</td>
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<td>56</td>
<td>31</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>242</td>
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<tr>
<td>Slovenia</td>
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<td>19</td>
<td>40</td>
<td>9</td>
<td>2</td>
<td>0.02</td>
<td>11</td>
<td>178</td>
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<tr>
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<td>3,738</td>
<td>834</td>
<td>1,437</td>
<td>308</td>
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<td>0</td>
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<td>805</td>
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<td>Switzerland</td>
<td>477</td>
<td>203</td>
<td>70</td>
<td>34</td>
<td>0</td>
<td>1</td>
<td>22</td>
<td>806</td>
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<tr>
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<td>1,151</td>
<td>2,845</td>
<td>187</td>
<td>0</td>
<td>378</td>
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</tbody>
</table>

Overall, pigs, cattle, poultry and sheep/goats accounted for 32%, 31%, 14% and 14%, of the PCU in the 30 countries.

In total, 25 countries provided data for all years between 2011 and 2016. For these countries an overall decline in sales (mg/PCU) of 20.1% was observed. Sales fell from 162.0 mg/PCU in 2011 to 129.4 mg/PCU in 2016. A fall in sales (in mg/PCU) of more than 5% was observed in 16 of these countries (in the range -8.7% to -57.8%), whilst there was an increase of more than 5% in six countries during the reference period (a range from 7.9% to 67.7%)
The European Centre for Disease Prevention and Control (ECDC)/European Food Safety Authority (EFSA)/EMA second joint report on the integrated analysis of the consumption of antimicrobial agents and occurrence of AMR in bacteria from humans and food-producing animals (JIACRA II report), while recognizing the complexity of evaluating the association between the sales of antimicrobials and occurrence of AMR in animals and humans, confirms that reduction of the sales of antimicrobials is a desirable objective in order to contain AMR.

EFSA, ECDC and EMA have jointly established a list of harmonized outcome indicators to assist EU Member States in assessing their progress in reducing the use of antimicrobials and occurrence of AMR in both humans and food producing animals.

1.10 Antimicrobial resistance and the food chain

Investigating the zoonotic antimicrobial resistance problem in its full complexity requires monitoring of antimicrobial usage and resistance in all relevant reservoirs and stages in the transmission route. Already in the early 1960, findings of resistant Salmonella in food animals and humans, and studies that showed that they could pass their resistance traits on to other enteric bacteria. In the mid-1990s the detection of vancomycin-resistant Enterococcus faecium as well as quinolone-resistant Salmonella and Campylobacter in food animals and evidence of their spread to humans elevated the scientific and public concerns to new levels. (Wegener, 2012)

Recently a number of antimicrobial-resistant pathogens have emerged in the food-production chain: extended beta-lactamase producing Salmonella and Escherichia coli, transmissible quinolone resistance in Salmonella and E.coli and animal-associated methicillin-resistant Staphylococcus aureus (MRSA), which can transmit to, and cause infections in humans. These emergences can all associated with the use of antimicrobial agents in food animals. (Aarestrup et al., 2008)
Foods of animal origin are considered to be an important source of antimicrobial-resistant bacteria entering the food chain (EFSA 2008). The main focus of concern the acquired resistance by the animal on the farm. Foods of animal origin may also act as a potential vehicle for human-to-human transmission of antimicrobial-resistant bacteria. Foods of non-animal origin are recognized as an important source of foodborne infection in Europe. Based on reported European outbreak data from 2007 to 2011, foods of non-animal origin were associated with 10% of the outbreaks (EFSA 2013). EFSA identified *Salmonella* spp in leafy greens, tomatoes, melons; Escherichia Coli in fresh pods, legumes or grains. Foods of non-animal origin may become contaminated during primary production or at a later stage.

1.11.1 Import of food of animal origin

Food of animal origin from third countries can only be imported into EU from approved processing plants (EC, 2006). The third countries production systems need to be compliant with the equivalent standard and is verified through audits by the Food and Veterinary Office of the EU Commission Directorate-General for Consumer Health and Protection (DG-SANTE, 2010).

Imported food is being verified by the official control at the borders and sent for laboratory analysis carried in the EU Border Inspection Posts.

1.11.2 Import of non-animal origin

Depending on the risk level, food of non-animal origin is going through three levels of control. There is free movement within the EU of food of non-animal origin produced in EU. Routine official controls are carried out on all products of non-animal origin entering the EU from the third countries unless a high risk is identified, and controls are increased. Increased controls are carried under the Regulation (EC) No 669/2009. Certain foods are verified to check the compliance with specific EU legislation, e.g. mycotoxins, pesticide residues and microbiological safety. (DG-SANTE, 2010)

As there is no EU standard for Antimicrobial-resistant bacteria in food, consideration for sampling for AMR are not part of the border control process. Once a product entered EU, is free to circulate with no restriction.
1.11.3 Water and Primary Production

Drinking water can act as a direct vehicle for transmission of antimicrobial-resistant bacteria when contaminated with animal or human faeces and can also be a potential vehicle for antimicrobial residues. Waterborne contamination of food may arise during primary production, e.g. contaminated irrigation water on crops, or food processing e.g. a contaminated ingredient. (FSAI, 2015). Disposal of manure and slurry on farms is also a concern which is being regulated by the Statutory Instrument No.610 of 2010 for the protection of waters.

Both human and animal by-products are a potential source of environmental contamination with antimicrobial-resistant bacteria which may impact on animal feed and food. These materials are of particular concern when spread on land where ready-to-eat crops are grown. Animal manures and municipal sludge have been shown to contain antimicrobial-resistant bacteria. When antibiotics are administered to an animal, some parts of the antimicrobial may be shed in urine, faeces and other body fluids. This may lead to a selection of resistant bacteria.

In a recent UK study, 83% of farmers fed milk from cows with mastitis to calves and only one third of these discarded the milk from the first milking after antimicrobial treatment (Brunton et al., 2012). High number of Swedish farmers also fed milk likely to contain antimicrobial residues to calves. The percentage of resistant faecal *E. coli* in calves fed such milk was higher than in calves fed milk without antimicrobial residues. (EFSA, 2016). Milk from animals which has been treated with antibiotics and which is temporarily redraw from the human food chain as a result of this treatment, is an animal by-product. If this milk is not used or disposed of the farm of origin, this is subject to ABP legislation Reg. EC. No.1069/2009.

Food handlers are also a potential source of antimicrobial-resistant organisms and may contaminate food. Therefore, food producing companies must implement and control Good Hygiene Practice, Good Manufacturing Practice and a HACCP plan to ensure the safety of the site. Inadequate cleaning of housing between flocks and herds may help disseminate antimicrobial-resistant bacteria.
1.12 Major pathogenic bacterial issues in the food chain

1.12.1 Salmonella

*Salmonella enterica* is a major cause of bacterial enteric illness in humans and animals and is notably the second leading cause of zoonotic infection in the European Union. (Gupta *et al.*, 2004)

In 2006, 1.3% of the raw poultry meat tested at the processing level was positive for *S. enterica*, followed by 5.3% in 2007. *S. Typhimurium* was the most frequently isolated serotype from pork and pork meat products in 2006 and 2007. A very low proportion of beef, veal and associated products were found to be contaminated with *S. enterica* at the processing level, compared to none at the retail level in 2006 and 2007. (SafeFood, 2010)

**Antimicrobial resistance in Salmonella spp.**

In Ireland, studies show an increase in antibiotic resistance in *Salmonella* spp. isolates from diseased animals, environment and feed-stuffs. A recent study of Salmonella spp. isolated from post evisceration pig carcasses and caecal contents, indicated a high incidence of *S. Typhimurium* in caecal contents (19%) and on carcasses (24%). (McDowell, 2007) The increased level of resistance to nalidixic acid is of clinical importance.

Porcine isolates tend to be resistant to a greater number of antibiotics than bovine or ovine, and turkey isolates are resistant to a greater number of antibiotics than chicken isolates. No resistance to third generation cephalosporins or ciprofloxacin have been detected in any animal isolates.

Intra-species differences may reflect on the intensity of the farming methods, for example, pigs are intensively reared indoors, where illness in one animal is easily spread through the herd, and the herd is being treated, whereas cattle or sheep are field farmed and are treated as individual animals.

The age of the infected animal is also important. Salmonella spp. from calves are significantly more resistant to antibiotics than from older bovine animals (EFSA, 2006), and the reason is unclear.

There is currently an outbreak of antibiotic-resistant Salmonella in the US from turkey that has infected 164 people across 35 states. The supplier has not been identified and the
outbreak has reached every turkey product from cold cuts to raw, whole turkey to pet food, according to mass media.

Another recent outbreak occurred in October 2018, where antibiotic-resistant Salmonella has sickened 92 people and has been traced to raw chicken from multiple sources and sold under various brands. Whole-genome sequencing of Salmonella isolates found in 43 of the patients and 68 food samples predicted the bacterial infection was resistant to multiple antibiotics. (CDC, 2018)

1.12.2 VTEC - Pathogenic E. coli

E. coli is arguably the best known and most intensively investigated group of the bacteria found in humans and warm-blooded animals. (Sungsu Park, 2001) Verocytotoxigenic Escherichia coli (VTEC), in particular serotype O157, are an important cause of gastrointestinal illness. They have emerged as significant pathogens causing a range of severe and fatal illnesses. Infection can be transmitted through food, contaminated water, the environment and by direct contact with animals or human. The presence of VTEC in food is of particular concern, as the minimum infection dose is estimated to be as low as 10 viable cells. (Walsh, 2010)

Antimicrobial resistance in VTEC

To date, antibiotic resistance in VTEC has received little research attention. This is mainly because antibiotic therapy is not recommended in case of VTEC-associated infection and VTEC-strains have been reported to be slower to acquire resistance than generic E. coli strains. However, multi-resistant strains of VTEC have been isolated from foods, suggesting increasing proliferation of antibiotic resistance among VTEC. (SafeFood, 2010) Some information is available based on the veterinary and human clinical cases which suggests that the incidence of antimicrobial resistant E. coli O157:H7 remains very low in cattle and sheep isolates, low in pig isolates, and with the exception of tetracycline, very low in human clinical isolates.

A study conducted in Romania in order to assess the antimicrobial resistance patterns of E. coli isolated from young animals between years 1980-2016 found that resistance to tetracycline and streptomycin was the most frequent co-resistance phenotype (37%).
Multi-drug resistance increased from 11% during 1980 to 40% between years 2000-2016. (Chirila et al, 2017)

1.12.3 Campylobacter

*Campylobacter* is the most commonly reported cause of bacterial foodborne infection in the EU followed by *Salmonella*. It can be transmitted to humans either directly or indirectly. Direct transmission can occur via contact with animals, carcasses or water which has been infected. Indirect transmission can occur through the ingestion of contaminated food or water. In the US, the highest risk factor for campylobacteriosis is the consumption of commercially-prepared chicken. (Rocourt, 2003)

Studies made in Ireland show that Campylobacter was isolated most frequently from retail poultry (chicken 49.9%, turkey 37.5% and duck 45.8%). However, data from EU showed that the incidence of *Campylobacter* spp in fresh poultry meat at slaughter ranged considerably from 4.6% to 56.1%.

Research has shown that by the third or fourth week of production, most poultry flocks are contaminated to some extent with *Campylobacter* spp, resulting in the eventual spread of the organism to almost all members of the flock. (Walsh, 2010)

Since consumption of poultry is one of the major risk factors in acquiring campylobacteriosis it is worth considering the impact of poultry processing on antibiotic resistance of this pathogen.

Slaughter and processing provide opportunities for reducing *C. jejuni* counts on food-animal carcasses. Bacterial counts on carcasses can increase during slaughter and processing steps. In one study, up to a 1000-fold increase in bacterial counts on carcasses was reported during transportation to slaughter.

Research studies carried out on chickens and turkeys at slaughter, found that bacterial counts increased by approximately 10 to 100-fold during defeathering with the highest level found after evisceration.

During the slaughter of cattle and swine, fresh carcasses are cooled by forced air ventilation. This treatment both temporally freezes and dries the surface, and this process has been documented to effectively reduce the number of *Campylobacter* cells on the surface of carcasses. Therefore, meat which is dried, cured, salted, smoked, irradiated or
exposed to any other preservation methods, will also harbor less *Campylobacter* compared to the unpreserved product.

Antimicrobial resistance is a common feature of *Campylobacter* isolated from food of animal and non-animal origin. In a European study in 2006, *Campylobacter* isolates from poultry meat were found to have a high level of resistance to ciprofloxacin (30.6%) (Piddock, 2006). Resistance to this antibiotic was also high in isolates from fowl, pigs, and cattle.

Resistance to tetracycline was found to be very common (EFSA, 2006). In food animals, the prevalence of resistance to erythromycin is generally higher in *C. coli*, in particular in *C. coli* isolates from pigs than in *C. jejuni*. (Enberg et al., 2001)

In Spain, it was found that the rates of erythromycin and quinolone resistance in *C.coli* from pigs were 81% and 100% (Saenz et al., 2000)
Antibiotics used in high concentrations in animal feed can be found in animal manure, which can end up as plant fertilizer.

It has been reported that a high proportion of animal *Campylobacter* spp are resistant to ampicillin/tetracycline (>40%) and ciprofloxacin/nalidixic acid (>20%). A report of Randall et al., suggested that 3.8% of *Campylobacter* spp. from combined human and animal origins were multi-resistant.

In general, *Campylobacter* spp isolated from pork and poultry have higher and broader resistance to antibiotics than lamb or beef. This may be due to the intensive farming methods used in pig and poultry rearing, where mass medication is relatively common and high stocking levels may facilitate dissemination of pathogens and AMR genes between animals. (Turnidge, 2004)

Most cases of human *Campylobacter* enteritis do not require antimicrobial treatment, as the symptoms are usually clinically mild. A survey conducted in Ireland, found that only 7.4% of those with acute gastroenteritis reported were taking antibiotics (Walsh, 2010). However, this can get to a more severe illness including diarrhoea, abdominal cramps and vomiting which can last for days. The use of quinolones (ciprofloxacin) is considered to be the first choice as they are also considered useful for the prophylaxis of travellers diarrhea. (Piddock, 2006)
There are examples from many countries where fluoroquinolones-resistance rates are similar in isolates from poultry products and humans (Saenz et al., 2000)

1.13 Antimicrobial Resistance and the Consumer

1.14.1 Antibiotics and general public

One of the most important steps in fighting antimicrobial resistance is revising the knowledge of the general public. Educational campaigns for the public play a vital role in this area. Creating a good campaign requires actual knowledge of the target population and continual assessment of the campaign’s effectiveness. European studies as well as international studies on the social knowledge of antibiotic use and antimicrobial resistance indicate a widespread ignorance regarding the ineffectiveness of antibiotic treatment for viral infections along with the knowledge of the difference between bacteria and viruses. Studies from Kuwait and Sweden confirm a confusion among the public regarding whether antibiotics are effective against bacteria or viruses. A study conducted in USA shows that a high percentage of respondents not only did not understand the difference between viral and bacterial infections, but also did not understand the indications for antibiotic treatment.

The world literature indicated that the percentages of bacterial resistance to antibiotics is correlated with the intensity of usage of these drugs. Therefore, self-medication plays an important role in driving resistance. Two types of behaviours are known to contribute to this phenomenon: obtaining antibiotics from pharmacy without a prescription or obtaining them from a non-medical source (e.g. leftover from previous course).

According to the Eurobarometer 478 Report, published in November 2018 on Antimicrobial Resistance the main findings across the European Union countries were:

- 32% of Europeans took antibiotics in the last 12 months
- 20% of Europeans took antibiotics for flu and cold
- 7% of them took antibiotics without a prescription or seeing a medical practitioner.
- 41% of them took antibiotics after a diagnosis test
- 85% are aware that unnecessary use of antibiotics makes them become ineffective
- 56% agree that sick animals should be treated with antibiotics if appropriate
- 38% are aware of the EU ban on the use of antibiotics for stimulating growth in farm animals
The report concludes that there has been a small drop since 2016 in the proportion of Europeans taking antibiotics in the previous 12 months and it is now at its lowest level since 2009. (40% in 2009 and 32% in 2018). (EC, 2018)

Overall, there remains significant scope to improve Europeans Knowledge about antibiotics reflecting the surveys findings. The challenge remains to reduce the overuse of antibiotics and reduce incorrect usage.

1.14.2 Consequences of foodborne antimicrobial resistance for the consumer

Antimicrobial resistant pathogenic bacteria may be ingested by consumers and present a immediate risk for public health. The consequences of antimicrobial resistant Salmonella and Campylobacter have been studies repeatedly. The studies revealed that the emerging resistance of these foodborne pathogens result in an increase in the number of hospitalizations and increase the risk of invasive infections and mortality.

Antimicrobial resistant genes present in foodstuff, either contained in bacteria and bacteriophages or as DNA fragments, may involve an indirect risk for public health as they increase the gene pool from which pathogenic bacteria can pick up antimicrobial resistance genes and possibly transfer them to other bacteria. (Verraes et al, 2013)

In vitro studies demonstrated the transfer of erythromycin resistance genes from LAB to *Listeria* spp.

Antimicrobial resistance in commensals constitutes and indirect public health risk as antimicrobial resistance may be transferred to pathogens. *E. coli* strains which are ingested with food may contain extended spectrum Beta-lactamase genes that are located on mobile genetic elements. Therefore, it is possible that cephalosporin resistance is transferred to pathogens in the human digestive system.

*Colistin*-*E. coli* with plasmid mediate resistance has been recently reported in Denmark in imported frozen poultry and transmission through the food chain to humans has been demonstrated. Plasmid mediated resistance to colistin has also been identified in salmonellosis cases in humans in other European countries. (FSA, 2016)
CHAPTER 2: METHODOLOGY

2.1 Aims and Objectives

The aims of this survey were:

• An overview of public perception and antibiotic resistance
• Examination of antibiotic use by the consumer
• To examine the frequency of antibiotic intake
• To determine consumer’s source of antibiotics
• To determine current awareness of antibiotic resistance
• To determine consumers perception towards the association between antibiotic use in food producing animals and bacterial infections in humans

2.2 Methods

2.2.1 Methodology

In order to meet the listed objectives, research was conducted through the distribution and completion of questionnaires by members of the public.

2.2.2 Questionnaire Design

A questionnaire was developed to determine consumer perception of antibiotics use and the antibiotic resistance problem. The questionnaire consisted of 22 questions. The questionnaire was created directly on Google Forms.

2.2.3 Question Structure

Self-completion questionnaires were chosen as they are the most common way of collecting data. They can be opened or closed questions. The author chose the closed question technique. The respondent is asked a question and required to answer. They provide a range of answers and so reduce the chance that the respondent will give an ambiguous answer (Moore, 2000)
A 22-question survey (as per Appendix 1) was designed to analyze consumer’s perception and knowledge on antibiotic use and antibiotic resistance. The survey had an approximate 7-minute completion time.

The Google Form survey was available from the 11th of October until 26th of November and 763 completed forms were collected. The completed forms were analyzed and transformed into graphical presentations (pie charts and bar charts). Findings were also recorded in an Excel database and statistically analyzed in SPSS.

2.2.4 Research population
There was no restriction in target participants. The questionnaire was targeted for general public, based in Ireland.

2.2.5 Pilot Study
A pilot study was carried out to determine whether the terminology, wording and content of the questionnaire was satisfactory. It was important that only relevant questions were asked and that they linked directly with the objectives required. The pilot study was carried out on 5 consumers.

The pilot study identified issues related to question and answer structure. For example, question 20, 3 out of 5 respondents notified a ranking scale of 1 to 3 instead of 1 to 5 as initially set. The author identified the scale error on mobile devices only. In order to avoid any confusions and facilitate the completion of the questionnaire both on mobile and online the author change the question ranking scale from 1 to 5 to 1 to 3. Following post trial, the author amended the issues identified.

2.2.6 Questionnaire Circulation
It was decided on the approach of an online questionnaire to be circulated on multiple online platforms such as emails, Facebook and WhatsApp. The highest number of responses came from social media. The author posted the survey link on various groups on Facebook. The response rate was surprisingly high with 600 responses recorded in 36 hours following link distribution on social media.

The survey was distributed on social media and included residents from Ireland. The author received positive feedback on the selected topic.
2.2.7 Data analysis

The results from the survey could be viewed as soon as the questionnaire was completed by the participant and submitted online. The number of responses received at any time could be checked by simply logging onto the site and viewing the status of the survey. Upon reaching the deadline for the completion of the survey, all 763 were analyzed using advanced software functions of Google Forms and Excel. The data was further analyzed by using SPSS, which is an advanced statistical tool.
CHAPTER 3: RESULTS

Survey Question 1. What is your gender?

<table>
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</thead>
<tbody>
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<td></td>
<td>Frequency</td>
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<td>Male</td>
<td>155</td>
</tr>
<tr>
<td>Female</td>
<td>608</td>
</tr>
</tbody>
</table>

Table 4. Gender distribution of respondents

Figure 5. Demographic profile of respondents: Gender (n= 763)

As given in the table 1, out of 763 people that completed the questionnaire, 79.8% of these were female and 20.2% were male. Research show that females are more inclined to complete a survey on antibiotics than males.
Survey Question 2: What is your age?

<table>
<thead>
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<th>Age group</th>
<th>Research Sample (n=763)</th>
<th>Percentage</th>
</tr>
</thead>
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<td>18 to 29 years</td>
<td>284</td>
<td>45%</td>
</tr>
<tr>
<td>30 to 49 years</td>
<td>290</td>
<td>49%</td>
</tr>
<tr>
<td>50 to 64 years</td>
<td>35</td>
<td>5%</td>
</tr>
<tr>
<td>Over 65 years</td>
<td>2</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Table 5. Age distribution of respondents (n=763)

Figure 6. Demographic profile of respondents: Age group (n=763)

Figure 2 presents the profile of the respondents in terms of their age. Out of 764 respondents, 49% are in the age range of 30-49 years old, 45% are young adults 18-29 years old and a small percentage 5% for age range 50-64%. Only 2 respondents over 65 years old.
Survey Question 3: What is the highest level of education you have completed?

- Others consisted of: “foundation degree”; “high-school”; “nursing”

Figure 7. Level of education (n=763)

Figure 3 shows that the vast majority of the respondents (34%) had a certificate/diploma, followed by Bachelor’s Degree with 32.8%, 24.9% had a Postgraduate Degree, and a small percentage 7.5% completed Secondary level.
Survey Question 4: How would you typically treat the first symptoms of an illness?

![Survey Question 4 Diagram]

**Figure 8. Consumer’s response to the first symptoms of an illness (n=763)**

As shown in the figure above the vast majority of the respondents (57.3%) are trying to avoid taking antibiotics to treat the first symptoms of an illness, unless is absolutely necessary. The other 25.5% of respondents are trying to manage without the antibiotic but would consider it in cases e.g. ‘if an infection worsens’ and 13.8% are even using alternative treatments such as holistic medicine to treat the illness. These results indicate a reticence among the majority of consumer to take antibiotics, unless necessary, suggesting an awareness of the impact of antibiotic overuse.
Survey Question 5: How often would you typically take antibiotics in a year?

Figure 9. The frequency of antibiotic intake (n=763)

Figure 5 finds that 49.2% of the respondents take antibiotics usually once or twice a year. A group of 41.5% responded that practically they never take antibiotics. For 55 respondents (7.2%) their antibiotic intake is from three to four times a year, and there is also minority group that are taking antibiotics more than three to four times a year.
The relationship between age group and frequency of antibiotic intake

Crosstabs – Table 6

Table 6a

<table>
<thead>
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<th>5. How often would you typically take antibiotics in a year?</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>1</td>
</tr>
<tr>
<td>2. What is your age?</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>187</td>
</tr>
<tr>
<td>1</td>
<td>170</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>376</td>
</tr>
</tbody>
</table>

Table 8b

Vertical axis; Age (0=18-29 years old; 1=30-49 years old; 2= 50-64 years old; 3=over 65 years old)

Horizontal axis; Frequency of antibiotic intake (0=usually once or twice a year; 1=usually 3 or 4 times a year; 2=usually more than that (>3-4); 3=practically never)

Chi-Square Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>df</th>
<th>Asymptotic Significance (2-Sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>28.019*</td>
<td>9</td>
<td>.001</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>29.674</td>
<td>9</td>
<td>.000</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>13.315</td>
<td>1</td>
<td>.000</td>
</tr>
</tbody>
</table>

N of Valid Cases | 763

a. 6 cells (37.5%) have expected counts less than 5. The minimum expected count is 1.6.

Table 6c

Pearson Chi-Square test was conducted independently to ascertain the relationship between age groups and antibiotic intake. which was found to be statistically significant (p<0.001)
Survey Question 6: Have you taken antibiotics in the last 12 months?

![Pie chart showing the intake of antibiotics in the last 12 months.](image)

**Figure 10. The intake of antibiotics in the last 12 months (n=763)**

The figure above represents the respondent’s intake of antibiotic in the last 12 months. The answer was quite balanced, the highest percentage 49.5% responded positive and a very close percentage did not take any antibiotics in the last 12 months.
Survey Question 7. How did you obtain the last course of antibiotics used?

* Others consisted of: “over the counter”, “friends”, “pharmacists”

Figure 11. Source of antibiotic course (n=763)

Figure 11 shows that the majority of the respondents obtained their last course of antibiotics with a medical prescription from a qualified health care practitioner. 48 respondents had leftovers from the previous course which they used and 2.5% had selected other, such as buying the medication abroad over the counter. Some respondents use somebody else’s prescription, and some would not take antibiotics at all.
Survey Question 8: When do you generally discontinue the antibiotic course?

Four out of five respondents (79.7%) correctly say that antibiotic treatment should only be stopped when all the antibiotics have been taken as directed. Nevertheless, around 1 in 8 respondents (19%) incorrectly think that they should stop taking antibiotics when they feel better.

- **Others consisted of:** ‘‘after a few days’’

Figure 12. Discontinuation of antibiotic course (n=763)
Survey Question 9: Would you consider taking a probiotic after an antibiotic course?

![Figure 13. Probiotic intake after an antibiotic course (n=763)](image)

The majority of the survey respondents would consider taking a probiotic after an antibiotic course. Almost a third of respondents would not consider taking probiotics and 15.7% are not sure, even though it is scientifically analysis shows that probiotics help with recovery after an antibiotic course.
Survey Question 10: Would you consider taking an antibiotic for a cold or flu?

Figure 14. The use of antibiotic for a cold or flu (n=763)

Figure 14 shows that the majority of respondents would not take antibiotics for a cold or flu, 14% said that maybe they would and 7.6% of the respondents would take antibiotics for a cold/flu.
Survey Question 11: In your opinion, are antibiotics effective against viral infections?

This figure shows the consumers personal opinion on the effectiveness of antibiotics against viral infections. Almost half of the respondents answered that the antibiotics are not effective against viral infections, 18.4% answered positive and the a third of them were unsure of the effect.

Figure 15. Antibiotics against viral infections (n=763)
The relationship between the level of education and consumers opinion if antibiotics are effective against viral infections

Crosstab – Table 7

**Case Processing Summary**

<table>
<thead>
<tr>
<th>Valid</th>
<th>Cases Missing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Percent</td>
<td>N</td>
</tr>
<tr>
<td>763</td>
<td>100.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7a

**Count**

| 11. In your opinion, are antibiotics effective against viral infections? |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                  | 0 | 1 | 2 | 3 | Total |
| 3. What is the highest level of education you have completed? *11. In your opinion, are antibiotics effective against viral infections? |
| 0                | 12 | 22 | 11 | 12 | 57 |
| 1                | 56 | 101 | 75 | 27 | 250 |
| 2                | 39 | 125 | 59 | 27 | 250 |
| 3                | 33 | 111 | 35 | 12 | 191 |
| 4                | 0 | 3 | 2 | 1 | 6 |
| Total            | 140 | 362 | 182 | 79 | 763 |

Table 7b

Vertical axis; Level of education (0=Secondary level; 1=Certificate/Diploma; 2=Bachelor’s Degree; 3=Postgraduate Degree; 4=Others)

Horizontal axis; Are antibiotics effective against viral infections? (0=yes; 1=no; 2=sometimes; 3=I don't know)

**Chi-Square Tests**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymptotic Significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>29.406a</td>
<td>12</td>
<td>.003</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>29.519</td>
<td>12</td>
<td>.003</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>3.204</td>
<td>1</td>
<td>.073</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>763</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 4 cells (20.0%) have expected counts less than 5. The minimum expected count is 6.2.

Table 9c

Pearson Chi-Square test was conducted independently, and got a value of p=0.003, which was found to be statistically significant (p<0.001)
Survey Question 12: In your opinion, does the unnecessary use of antibiotics make them become ineffective?

![Pie chart showing responses to survey question](image)

**Figure 16. Unnecessary use of antibiotics makes them become ineffective (n=763)**

More than 1 in 5 respondents (81.6%) correctly say that in their opinion it is true that unnecessary use of antibiotics makes them become ineffective, 10% of the respondents did not know and 7.9% said that they do not become ineffective.
The relationship between consumers opinion if the unnecessary use of antibiotic make them become ineffective and their awareness of the term Antibiotic Resistance

Crosstabs- Table 8

| Case Processing Summary | Valid | | Cases | Missing | | Total | |
|-------------------------|-------|---|-------|---------|---|-------|
|                         | N     | Percent | N     | Percent | N     | Percent |
| 13. Have you heard of the term Antibiotic Resistance?**12. In your opinion, does the unnecessary use of antibiotics make them become ineffective? | 753   | 100.0% | 0     | 0.0%    | 753   | 100.0% |

Table 8a

Count

<table>
<thead>
<tr>
<th>12. In your opinion, does the unnecessary use of antibiotics make them become ineffective?</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Have you heard of the term Antibiotic Resistance?</td>
<td>0</td>
<td>540</td>
<td>33</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>69</td>
<td>24</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>623</td>
<td>60</td>
<td>80</td>
<td>763</td>
</tr>
</tbody>
</table>

Table 8b

Vertical axis; Awareness of the term Antibiotic Resistance (0=yes; 1=no; 2= I don’t know)

Horizontal axis; Unnecessary use of antibiotics make them become ineffective (0=yes; 1=no; 2= I don’t know)

Chi-Square Tests

<table>
<thead>
<tr>
<th>Value</th>
<th>df</th>
<th>Asymptotic Significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>86.545 (^a)</td>
<td>4</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>71.035</td>
<td>4</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>72.730</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^a\) 2 cells (22.2%) have expected count less than 5. The minimum expected count is 2.12.

Table 8c

Pearson Chi-Square test was conducted independently, and got a value of p=0.000, which was found to be statistically significant (p<0.001)
Survey Question 13. Have you heard of the term Antibiotic Resistance?

Figure 17. Antibiotic Resistance awareness (n=763)

Four out of five respondents (80.6%) have heard of Antibiotic Resistance, almost a quarter have never heard anything about it at all.
The relationship between the level of education and the awareness of the Antibiotic Resistance term

Crosstabs – Table 9

**Case Processing Summary**

<table>
<thead>
<tr>
<th>N</th>
<th>Percent</th>
<th>N</th>
<th>Percent</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Valid</strong></td>
<td><strong>N</strong></td>
<td><strong>Percent</strong></td>
<td><strong>Missing</strong></td>
<td><strong>N</strong></td>
<td><strong>Percent</strong></td>
</tr>
<tr>
<td>3. What is the highest level of education you have completed? *</td>
<td>763</td>
<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
<td>763</td>
</tr>
</tbody>
</table>

Table 9a

**Count**

<table>
<thead>
<tr>
<th>13. Have you heard of the term Antibiotic Resistance?</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. What is the highest level of education you have completed?</td>
<td>0</td>
<td>40</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>196</td>
<td>54</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>205</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>169</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>615</td>
<td>121</td>
<td>27</td>
<td>763</td>
</tr>
</tbody>
</table>

Table 9b

Vertical axis; Level of education (0=Secondary level; 1=Certificate/Diploma; 2=Bachelor’s Degree; 3=Postgraduate Degree; 4=Others)

Horizontal axis; Awareness of the Antibiotic Resistance term (0=yes; 1=no; 2= I don’t know)

**Chi-Square Tests**

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>df</th>
<th>Asymptotic Significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>20.299</td>
<td>8</td>
<td>.000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>19.265</td>
<td>8</td>
<td>.014</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>9.725</td>
<td>1</td>
<td>.002</td>
</tr>
</tbody>
</table>

Table 9c

Pearson Chi-Square test was conducted independently, and got a value of \( p = 0.009 \), which was found to be statistically significant (\( p < 0.001 \))
Survey Question 14. What is your level of concern regarding antibiotic resistance?

Figure 18. Consumers level of concern regarding antibiotic resistance (n=763)

Figure 18 shows a mix of answers, 44.5% are very concerned followed by 30.4% of respondents that are not that concerned and 25.1% never even thought about Antibiotic Resistance.
The relationship between the level of concern regarding antibiotic resistance and the availability of public awareness campaigns

Crosstab – Table 10

**Case Processing Summary**

<table>
<thead>
<tr>
<th>Valid</th>
<th>Cases Missing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>Percent</td>
<td>N</td>
</tr>
<tr>
<td>763</td>
<td>100.0%</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>763</td>
</tr>
</tbody>
</table>

Table 10a

Count

<table>
<thead>
<tr>
<th>14. What is your level of concern regarding antibiotic resistance?</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>254</td>
<td>37</td>
<td>49</td>
<td>340</td>
</tr>
<tr>
<td>1</td>
<td>154</td>
<td>42</td>
<td>36</td>
<td>232</td>
</tr>
<tr>
<td>2</td>
<td>122</td>
<td>24</td>
<td>45</td>
<td>191</td>
</tr>
<tr>
<td>Total</td>
<td>530</td>
<td>103</td>
<td>130</td>
<td>763</td>
</tr>
</tbody>
</table>

Table 9b

Vertical axis; Level of concern regarding antibiotic resistance (0=very concerned; 1=not that concerned; 2=never thought about it)

Horizontal axis; Rating of public awareness campaigns availability (0=poor; 1=good; 2=none)

**Chi-Square Tests**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymptotic Significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>14.473^a</td>
<td>4</td>
<td>.006</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>13.914</td>
<td>4</td>
<td>.008</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>8.391</td>
<td>1</td>
<td>.004</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>763</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 25.78.

Table 10c

Pearson Chi-Square test was conducted independently, and got a value of p=0.006, which was found to be statistically significant (p<0.001)
Survey Question 15: Do you think that antibiotic resistance is a problem that you may have to deal with in this lifetime?

Figure 19. Consumers Perception on Antibiotic Resistance Problem (n=763)

Figure 15 shows that almost half of the respondents (41.9%) related that this is quite possible that they will have to deal with the antibiotic resistance problem, a third of the respondents say that is less likely but it is a problem for the next generation while 21% do not think they may encounter this problem.
Survey Question 16: In your opinion, what is the underlying concern associated with antibiotic resistance?

![Pie chart showing survey responses]

**Figure 20. The underlying concern associated with the antibiotic resistance (n=763)**

Figures 16 shows that half of the respondents think that the main concern associated with antibiotic resistance is that it may result in untreatable infections, with a higher number of fatalities. A quarter of the respondents think that it may result in sicker patients and longer hospital stays, until an effective antibiotic is given and the 21% of the respondents think that the antibiotic is failing to work and the doctor will need to prescribe a new one.
Survey Question 17: What is your level of concern about the use of antibiotics in animal feed?

![Pie chart showing consumer's level of concern about antibiotics in animal feed](image)

**Figure 21. Consumers level of concern about the use of antibiotics in animal feed (n=763)**

Figure 21 presents the consumer’s level of concern about the use of antibiotics in animal feed. Surprisingly, a very high percentage did not think about it during their lifetime. However, the majority of respondents are very concerned about the antibiotic use in animal feed.
Survey Question 18: Do you think that antibiotic use in food producing animals can indirectly affect the treatment of bacterial infections in humans?

![Pie chart showing responses to Survey Question 18]

Figure 22. Antibiotic use in food producing animals can indirectly affect the treatment of bacterial infections in humans (n=763)

Figure 22 shows that more than half of the total respondents (64.3%) think that there is a relation between antibiotic use in food producing animals and the treatment of bacterial infections in humans. A quarter of the respondents (26.5%) were unsure about the whole process of transmission and 9.2% responded negative.
Relationship between Level of concern about the use of antibiotics in animal feed and consumers opinion if they think the use of antibiotic in food producing animal can indirectly affect the treatment of bacterial infections in humans

Crosstab – Table 11

**Case Processing Summary**

<table>
<thead>
<tr>
<th></th>
<th>Valid</th>
<th></th>
<th>Missing</th>
<th></th>
<th>Total</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
</tr>
<tr>
<td>17. What is your level of concern about the use of antibiotics in animal feed? * 18. Do you think that antibiotic use in food producing animals can indirectly affect the treatment of bacterial infections in humans?</td>
<td>763</td>
<td>100.0%</td>
<td>0</td>
<td>0.0%</td>
<td>763</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

**Table 11a**

**Count**

<table>
<thead>
<tr>
<th>18. Do you think that antibiotic use in food producing animals can indirectly affect the treatment of bacterial infections in humans?</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>17. What is your level of concern about the use of antibiotics in animal feed?</td>
<td>0</td>
<td>301</td>
<td>25</td>
<td>37</td>
</tr>
<tr>
<td>1</td>
<td>91</td>
<td>26</td>
<td>42</td>
<td>159</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>19</td>
<td>123</td>
<td>241</td>
</tr>
<tr>
<td>Total</td>
<td>491</td>
<td>70</td>
<td>202</td>
<td>763</td>
</tr>
</tbody>
</table>

**Table 11b**

Vertical axis; Level of concern about the use of antibiotic in animal feed (0=very concerned; 1=not that concerned; 2=never thought about it)

Horizontal axis; (0=yes; 1=no; 2=I don’t know)

**Chi-Square Tests**

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymptotic Significance (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>143.892&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>143.012</td>
<td>4</td>
<td>.000</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>130.013</td>
<td>1</td>
<td>.000</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>763</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> 0 cells (0.0%) have expected count less than 5. The minimum expected count is 14.50.

**Table 11c**

67
Pearson Chi-Square test was conducted independently, and got a value of $p=0.000$, which was found to be statistically significant ($p<0.001$).

Survey Question 19: Would you choose organic meat products over conventional meat products if they were the same price?

![Figure 23. Consumers choice between organic meat products over conventional meat products (n=763)](image)

The respondents were asked if they would choose organic meat products over the conventional meat products if they were the same price and followed by a reason for their choice. The respondents were allowed to tick more than one answer. More than half of the respondents would choose organic meat products because they consider organic meat a superior product. Almost half of the respondents would choose organic meat as they are concerned about antibiotics use in food producing animals. Two hundred and four respondents would choose organic meat for animal welfare reasons. Fifty eight responded that they would still select conventional products.
Survey Question 20: How would you prioritize the following practices to reduce antibiotic resistance?

(1-highest, 2-medium, 3-lowest)

![Figure 24. Practices to reduce antibiotic resistance (n=763)](image)

Respondents were asked to prioritize five practices to reduce antibiotic resistance from 1 - the highest priority to 3 - the lowest priority. Each respondents had to prioritize each of the five practices. Following the analysis of the responses, consumers think that the highest priority practice is that the doctor should prescribe antibiotics only when absolutely necessary (562 respondents ranked this practice as highest priority), followed by more public awareness campaigns to explain antibiotic resistance (509 respondents ranked this as highest priority). Only 272 respondents chose that investing in the research to develop new antibiotic to replace those that are ineffective as the highest priority.
Survey Question 21: How would you rate the availability of public awareness campaigns regarding the use of antibiotics and antibiotic resistance?

![Pie chart showing availability of public awareness campaigns](image)

**Figure 25. Availability of public awareness campaigns (n=763)**

Respondents were asked to rate the availability of public awareness campaign regarding the use of antibiotics and antibiotic resistance which is presented in Figure 21. Almost all the respondents said that the availability of public awareness campaigns is poor, 17% of respondents rated the availability as being none at all.
Survey Question 22: How would you trust to be informed about antibiotic resistance? (Feel free to tick more answers if preferable)

*Others: Scientific Journals, Education, School etc.

Figure 26. Sources of information about antibiotic resistance (n=763)

Respondents were asked to give their opinion on which sources of information about antibiotics and antibiotic resistance are the most trustworthy.

A large majority of respondents see social media as a source of trustworthy information about antibiotics followed by television. Surprisingly, the general practitioner is not the top choice for the consumers.

Respondents also like be informed about antibiotic resistance at the radio or in newspapers.
CHAPTER 4: DISCUSSION

This chapter discusses the data which was obtained through a suitable survey addressed to consumers based in Ireland. The data has been analyzed using Microsoft Excel and SPSS for thorough construction of charts and cross tabulations which are presented in the results chapter of this study.

Reducing the overuse and misuse of antibiotics is vital to slow down and reduce antimicrobial resistance which has become a threat to public health in Europe and other parts of the world.

The behaviour, knowledge and attitude of the public is a key factor in ensuring the prudent use of antimicrobials.

1. Examination of antibiotic use by consumer

Findings from this study show that there are variations in the use of antibiotics by the consumers.

In particular, the majority of the respondents (57.3%) reported that they are trying to avoid taking antibiotics, unless it is absolutely necessary when treating an illness. This shows a certain level of awareness towards the overuse of antibiotics.

2. To determine frequency of antibiotic intake

Results show that 49.5% of the respondents have taken antibiotics during the last year, and the majority of the people surveyed take antibiotics usually once or twice a year (49.2%). Based on the 2018 Eurobarometer on Antibiotic Resistance, a third of Europeans (32%) have taken antibiotics in the last year. Across all Member States the highest frequency of antibiotic intake was reported in Italy (47%). The largest decrease have been observed in Romania (-10% versus 2016).

Socio-demographic and key variable analysis:

There are some notable differences between socio-demographic and key variable groups, most marked in relation to the respondents education level: Fifty seven percent of respondents who took antibiotics in the past year had Secondary level education, 55.7% Certificate/Diploma, 45.8% Postgraduate level and 45% Bachelor’s Degree. Other groups who are more likely to have taken antibiotics in the last year include the age group, 25%
age between 18-29 year old and 22% age between 30-49 year old out of the total 763 respondents. Also, secondary level respondents had the highest frequency of antibiotic intake per year, 14% of respondents would take antibiotics three to four times per year. Another important factor contributing to appropriate antibiotic use in consumers understanding of when to stop taking them. WHO (2017) advised that patients should always take the full course of antibiotics prescribed to them by a health care professional because a full course is required to kill all bacteria; stopping earlier favours those strains that have some resistance naturally. However, our study shows that 19% of the respondents stop taking the antibiotic course when they feel better and think they have taken enough antibiotic to treat the illness. There are notable socio-demographic differences regarding the discontinuation of antibiotics. According to this study, respondents with higher level of education are more likely to take the full course of antibiotics. According to the data analysis, 23% of the respondents who would interrupt the antibiotic course when they feel better they had a Certificate/Diploma and 14% had a Postgraduate Degree.

Understanding which conditions can be treated with antibiotics is also very important. Respondents were asked if they would consider taking an antibiotic for a cold or flu. The majority of respondents (78%) were aware that antibiotics do not treat a cold or a flu. According to the Eurobarometer 478 Report, published in November 2018 in Antimicrobial Resistance, 20% of the Europeans took antibiotics for flu and cold. There has been an improvement this year compared to 2016 when the percentage of Europeans who took antibiotics for flu and cold was 26%. Furthermore, respondents were asked if antibiotics are effective against viral infections. Almost half of the respondents correctly answered that antibiotics are not effective against viral infections. Data analysis encountered socio-demographic differences. Respondents with higher level of education (Postgraduate Degree) had a higher level of correct answers (58%) than lower levels of education with correct answers 39% (Secondary Level).

Findings show that 82% of the respondents know that unnecessary use of antibiotics make them become ineffective. It is notable that 10% were unsure of the correct answer and 8% stated that they do not become ineffective. According to the Eurobarometer 478 Report (EC, 2018), most Europeans (85%) are aware that unnecessary use of antibiotics can make them ineffective, however respondents in Romania (74%) and Italy (70%) are least likely to give the correct answer.
3. To determine consumers source of antibiotics

It is very important to identify how respondents obtain antibiotics because tackling AMR involves improving prescribing practices (limiting antimicrobial medicines so that they are available on a prescription basis and only prescribed when needed) and stopping self-medication.

Findings from this study show that the vast majority of the respondents (90.2%) obtained their last course of antibiotics used with a medical prescription from a qualified health care practitioner.

The results are quite similar with the Eurobarometer 478 (EC, 2018) on AMR results regarding the ways of obtaining antibiotics. The majority of Europeans obtained their last course of antibiotic through a healthcare professional via a medical prescription.

4. To determine current awareness of antibiotic resistance

The survey explored levels of awareness by asking respondents whether they had heard of the term Antibiotic Resistance, as it is essential that the public is aware of the importance of the issue of antibiotic resistance. The results show high levels of familiarity with the term. Overall, 80.6% of the total respondents stated they have heard the term Antibiotic Resistance before. The survey findings show some notable socio-demographic differences in relation to the awareness of the term antibiotic resistance.

• Respondents with a higher level of education are more likely to have heard of the term antibiotic resistance. Following the data analysis 24% of the respondents who stated that they did not hear about the term antibiotic resistance were secondary level graduates, 21% were Certificate/Diploma graduates, 14% had a Bachelor’s Degree and 9% of the respondents had a Postgraduate Degree.

• Respondents are most likely to have heard of the term if they are aged 30-49, with familiarity at 85%. This is significantly higher than those aged 18-29 (76%).

The survey sought to establish the level of concern regarding antibiotic resistance. It is notable that 30.4% of the respondents did not express concern regarding antibiotic resistance and 25.1% never even thought about this issue. This is concerning, as the problem of antibiotic resistance requires action from everyone, from members of the public and policy makers, to health and agricultural professionals.

Following the results of a multi-country public awareness survey on Antibiotic Resistance developed by WHO (2015), 57% of the respondents stated that There is not much people can do to stop antibiotic resistance, which is evidence that a more proactive approach is
required to improve societal understanding of antibiotic resistance including educating the public on step they should be taking. 

Survey respondents were also asked whether they think that antibiotic resistance is a problem that they might have to deal with in this lifetime. Almost half of the respondents (41.9%) related that it is quite possible that they will have to deal with the antibiotic resistance problem, while 24% stated that it might be a problem for the next generation. As mentioned before, Jim O’Neill published a review commissioned by the United Kingdom government entitled, “Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations (the AMR Review)” and estimated that antimicrobial resistance could cause 10 million deaths a year by 2050. It is acknowledged that there is a large clinical and public health burden associated with AMR and this burden is likely to increase over time which requires urgent action.

Respondents were given several practices which they had to prioritise to reduce antibiotic resistance and the top priority was “Doctor only prescribing antibiotics when absolutely necessary” and the least prioritised was “Investing in the research to develop new antibiotics to replace those that are ineffective”. This demonstrates that consumers prefer to prevent the issue rather than treat the problem which is a good approach. The second most voted statement was “More public awareness campaigns to explain antibiotic resistance” which would more than likely improve the lack of understanding and knowledge about the antibiotic resistance problem worldwide. In addition, it suggests that policy makers and stakeholders have a responsibility to assist in educating the public regarding this problem, and the effective measures that can be taken.

Respondents were asked to rate the availability of public awareness campaigns. Almost all the respondents stated that the availability of public awareness campaigns is poor, and 17% of respondents rated that the availability as being none at all. Recently in Ireland, on November 18, the HSE launched a new campaign to raise awareness on the correct use of antibiotics. It is accepted in Ireland and across Europe that action needs to be taken to curb growing resistance to antibiotics. The key message to the campaign is – “Antibiotics are wasted on colds and flu”. November 18 also marked the 4th European Antibiotic Awareness Day, which has the aim to emphasize the importance of only taking antibiotics when really needed and encouraging the public to follow their doctor and pharmacists instructions on how to take antibiotics in the appropriate way. The HSE is working with a range of partners in Ireland and across Europe to deliver a concerted effort to tackle inappropriate antibiotic use.
It was also vital to find out how would respondents trust to be informed about antibiotic resistance. The majority prefers to be informed by Social Media (69.8%), followed by Television (65%) and GP (49.4%). There is a notable difference between the study findings compared to the Eurobarometer 478 on Antimicrobial Resistance where the respondents are most likely to view medical professional or healthcare facilities as the most trustworthy sources of information on antibiotics. In more general terms, it does elucidate the most effective methods (social media, TV etc.) to communicate important information regarding this issue to the public.

5. To determine consumers perception towards the association between antibiotic use in food producing animals and bacterial infections in humans.

The survey established the level of concern regarding the use of antibiotics in animal feed. Half of the respondents (47%) are very concerned about the use of antibiotics in animal feed. Surprisingly, a very high percentage (32%) have not considered this problem to date and 21% were not that concerned. Data analysis showed that the majority of the respondents that were very concerned about the use of antibiotics in animal feed were also very concerned about antibiotic resistance (61.5%). Survey also shows that 39% of the respondents are more concerned about the use of antibiotics in animal feed rather (most likely from a toxicological perspective), than antibiotic resistance itself.

Respondents were asked if they think antibiotic use in food producing animals can indirectly affect the treatment of bacterial infections in humans. More than half of the total respondents think that there is a relation between antibiotic use in food producing animals and the treatment of bacterial infections in humans. When food animals are given antibiotic, resistant bacteria could emerge and multiply in the intestinal tract of the animal the same way that can happens in people when antibiotics are used to treat infections. Some of these bacteria in the food animal might contaminate the surface of meat during processing. If the meat is not thoroughly cooked to kill the bacteria, and enough organisms are present to infect a person, they could cause a food borne illness. If antimicrobial therapy is needed, and the causative organism are resistant, the drug may not be as effective in helping to cure the infection and prolonged illness could result (Doyle et al., 2006). Even though it is difficult for scientists to identify when this chain of events actually occurs, it is still considered a human food safety risk.

The survey also investigated consumers choice between organic meat products over conventional meat products. Respondents could chose more than one answer. More than
half of the respondents (54%) would choose organic meat because they consider it a superior product. Almost half of the respondents (47%) would choose organic meat because they are concerned about antibiotics used in food producing animals, 27% of respondents would choose organic meat for welfare reasons and 7.6% would still prefer the conventional meat.
CHAPTER 5: CONCLUSION

Following the survey conducted to assess the knowledge and perception with regards to the use of antibiotics and AMR among the residents in Ireland, the results indicate that not all the respondents have adequate information. However these findings provide valid elements to promote initiatives aimed at societal education regarding antibiotic use. Findings include specific knowledge gaps such as: antibiotics being against viruses; and that antibiotic treatment can end prior to course completion. It would be worthwhile for stakeholders and policymakers to issue guidance and assistance in addressing this misinformation.

The frequency of antibiotics intake was influenced by socio-demographic parameters and indicates that consumers with a lower level of education had the highest intake of antibiotics per year.

The study results show the diversity of public awareness regarding antibiotics and antimicrobial resistance on the basis of socio-demographic factors and indicated that consumers with lower level of education should be the main target of future educational campaigns.

The study also indicates that the vast majority of the survey respondents source their antibiotics accordingly with a medical prescription from a qualified healthcare practitioner.

According to the survey findings, respondents know there is an association between antibiotic use in food producing animals and bacterial infections in humans, and the majority of respondents would choose organic meat as it is a superior product.

Additional didactic and systematic education campaigns regarding appropriate use are needed and the Social Media and television as an education tool should be considered.

The European Commission has committed to continue to scale up its fight against AMR with the launch in June 2017 of a second action plan “A European One Health Action Plan against Antimicrobial Resistance (AMR)”. This new action plan will focus on supporting Member States, particularly in establishing, implementing and monitoring their national action plans. The plan will bring together EU funds and instruments in order to promote innovation and research in the area of AMR. The plan also aims to strengthen the EU’s global leadership role, notably with international organizations and major trading partners.
CHAPTER 6: RECOMMENDATIONS

1. Government
National, regional and local government, have the ultimately responsibility for developing, implementing, and supporting the policies, actions and structures necessary to ensure the prudent use of antibiotics. Their responsibility includes legislation, regulation and auditing compliance with legal, policy and professional standards. National strategies to combat AMR should be in line with the WHO Global Action Plan on AMR.

Government strategies should include the following key elements:

- Regulation of access and use of antibiotics.
- Antimicrobial stewardship programmes at all levels of care (community, hospitals).
- Qualitative and quantitative targets to improve antimicrobial prescribing.
- Education of health professionals.

2. Prescribers
Prescribers are ultimately responsible for the decision to use antibiotics in public health care. Prescribers should therefore be provided with training, guidelines and information in order to be able to exercise prudence in the prescribing of antibiotics.

Prescribers should include the following key elements:

- Make a diagnosis during an in-person patient consultation before prescribing antibiotics, except in exceptional circumstances.
- Ensure that appropriate microbiological samples are taken before starting antimicrobial treatment.
- Avoid antibacterial treatment when there is only evidence of viral infection or of a self-limiting bacterial infection.
- Use antimicrobial prophylaxis only when indicated in relevant guidelines.
- Select an antimicrobial with a spectrum of activity as narrow as possible.

3. Pharmacists
Pharmacists can act as an important source of advice and information for the public. The role of the pharmacist includes assessing the prescription in accordance with local policies for antimicrobial use; reviewing the antimicrobial duration; counselling on the use of restricted antimicrobials; giving advice on dosage.
- Only dispense antimicrobials with prescription, unless specific provisions allow for regulated dispensation in specific circumstances.
- Ensure that the patients understand the dosage and duration of treatment.
- Participate in health campaigns promoting the prudent use of antimicrobials.

4. Public

The knowledge, attitude and behavior of the public can be of profound importance in establishing and ensuring the prudent use of antimicrobials. Key elements for the public are:
- Inform themselves and, where needed, seek information from healthcare providers about appropriate antimicrobial use, antimicrobial resistance and adverse reactions to antimicrobials.
- Use antibiotics only when prescribed and complete the course where possible.
- Refrain from using antimicrobials which have not been prescribed such as leftover antibiotics, antibiotics prescribed for another person, or antibiotics prescribed without a prescription.

5. Professional associations and scientific societies

- Cooperate closely with the regulatory authorities in all relevant domains to ensure that the proposed measures to promote the prudent use of antibiotics are evidence-based and feasible.
- Promote prudent use of antibiotics through activities that include guideline development and training.
- Supporting information and awareness raising activities to promote the prudent use.
- Conduct relevant research.

6. Farmers

- Limit the prophylactic use of antimicrobials (i.e. as a preventing measure, in the absence of clinical signs of infection) to single animals, only when justified by a veterinarian in cases where there is a high risk of infection with severe consequences.
- Metaphylaxis use (i.e. treating a group of animals when one shows signs of infection) should happen only where no appropriate alternative exists, and after diagnosis and justification from a veterinarian.

Better farming practices, such as quality housing, ventilation, cleaning, disinfection and bio-security.
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A STUDY OF CONSUMER PERCEPTION OF ANTIBIOTIC RESISTANCE AND ANTIBIOTIC USE IN IRELAND

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Abstract

The development of antibiotic resistance is a globally recognised human health threat. Overuse and misuse of antibiotics are a major contributory factor to the development of antibiotic resistance. It is estimated that 10 million deaths due to AMR will occur every year after 2050. This equals the number of people dying of cancer every year in present times.

The public plays a role in antibiotic use and the development and spread of antibiotic resistance. The purpose of this study was to assess the knowledge of Irish consumers regarding antibiotic use. In detail, it looks at the use, frequency, source and awareness of antibiotics and antibiotic resistance.

A cross-sectional survey was designed to analyse consumers perception and knowledge on antibiotic and antibiotic resistance. It was decided on the approach of an online questionnaire to be circulated on multiple online platforms.

The findings are as follows: Fifty-seven percent of respondents are trying to completely avoid antibiotics, unless absolutely necessary. Half of respondents took antibiotics in the last 12 months. The majority of respondents obtained antibiotics through a valid medical prescription. A prevalence of 6% of self-medication with antibiotic mainly leftovers from previous course was reported. Almost 80% of the respondents discontinue the antibiotic treatment when all antibiotics have been taken as directed. Gaps in population understanding of antibiotics were observed. Only 47% of the respondents knew that
antibiotics were not effective against viruses. Eighty-two percent of respondents understood that unnecessary use of antibiotics make them ineffective. Almost 16% did not hear of the term Antibiotic Resistance.

It is important to note that there are some notable socio-demographic differences in relation to the frequency of antibiotic intake. Furthermore, this study suggests that an increase in educational degrees is correlated with the level of awareness. Although the study shows a certain level of understanding of the antimicrobial resistance problem, there still is a lack of knowledge, mostly reported by consumers with a lower level of education.

Methodology

A questionnaire was developed to determine consumer’s perception on antibiotics and antibiotic resistance. The questionnaire consisted in 22 questions. It was decided on the approach of an online questionnaire to be circulated on multiple online platforms. A total of 763 completed questionnaires were collected. The response rate was surprisingly high with 600 responses recorded in 36 hours following link distribution on social media. The questionnaire was targeted for general public, mainly residents from Ireland. All 763 responses were analyzed using advanced software functions of Google Forms and Excel. The data was further analyzed by using SPSS advanced statistical tool. The questionnaire was targeted for general public, based in Ireland.

Results

A total of 763 completed questionnaires were collected. Of 763 respondents, 79.8% were females and 20.2% were male. When queried about their antibiotic use fifty-seven percent (57%) of respondents are trying to completely avoid antibiotics, unless absolutely necessary. Half of respondents (50%) took antibiotics in the last 12 months. Interestingly, a prevalence of six percent (6%) of self-medication with antibiotic mainly leftovers from previous course was reported. Almost eighty percent (80%) of the respondents discontinue the antibiotic treatment when all antibiotics have been taken as directed. Only forty-seven percent (47%) of the respondents knew that antibiotics were not effective against viruses. When asked about antibiotic resistance awareness, sixteen percent (16%) did not hear of the term Antibiotic Resistance. Almost all the respondents stated that the availability of public awareness campaigns is poor. Finally the majority of respondents, seventy percent (70%), would trust to be informed about antibiotic resistance by social media.
Conclusion

Following the survey conducted to assess the knowledge and perception with regards to the use of antibiotics and AMR among the residents in Ireland, the results indicate that not all the respondents have adequate information. However these findings provide valid elements to promote initiatives aimed at societal education regarding antibiotic use. Findings include specific knowledge gaps such as: antibiotics being against viruses; and that antibiotic treatment can end prior to course completion. It would be worthwhile for stakeholders and policymakers to issue guidance and assistance in addressing this misinformation.

The frequency of antibiotics intake was influenced by socio-demographic parameters and indicates that consumers with a lower level of education had the highest intake of antibiotics per year. The study results show the diversity of public awareness regarding antibiotics and antimicrobial resistance on the basis of socio-demographic factors and indicated that consumers with lower level of education should be the main target of future educational campaigns.

The study also indicates that the vast majority of the survey respondents source their antibiotics accordingly with a medical prescription from a qualified healthcare practitioner. According to the survey findings, respondents know there is an association between antibiotic use in food producing animals and bacterial infections in humans, and the majority of respondents would choose organic meat as it is a superior product.

Additional didactic and systematic education campaigns regarding appropriate use are needed and the Social Media and television as an education tool should be considered.
Appendix 1: Survey Questionnaire on Consumers Perception on Antibiotic Use and AMR

Consumers Perception on antibiotic use and AMR

1. What is your gender?
   a) male
   b) female

2. What is your age?
   a) 18-29 year old
   b) 30-49 year old
   c) 50-64 year old
   d) 65 years or older

3. What is the highest level of education you have completed?
   a) Second level
   b) Certificate, Diploma etc.
   c) Bachelor’s Degree
   d) Postgraduate qualification e.g. MSc, PhD etc
   e) Other (Please specify)

4. How would you typically treat the first symptoms of an illness?
   a) take an antibiotic immediately to prevent onset of illness
   b) try to manage without the antibiotic, but consider it if infection worsens
   c) try to avoid taking antibiotics, unless absolutely necessary
   d) use alternatives such as holistic medicine to treat illness
   d) Others (Please specify)

5. How often would you typically take antibiotics in a year?
   a) Practically never
   b) usually about once, or twice a year
   c) usually 3 to 4 times a year
   d) usually more often than that (>3-4 times)

6. Have you taken any antibiotics in the last 12 months?
   a) Yes
   b) No
   c) I don’t know

7. How did you obtain the last course of antibiotics used?
   a) got a medical prescription
   b) old medical prescription
c) somebody else’s prescription
d) leftover from a previous course
e) Other, please specify

8. When do you generally stop taking antibiotics, once you commence treatment?
   a) when you feel better and think you have taken enough antibiotic to the treat the illness
   b) when you have taken all of antibiotic as directed
   c) Other, please specify

9. Would you consider taking a probiotic after an antibiotic course?
   a) Yes
   b) No
   c) I don’t know

10. Would you consider taking an antibiotic for a cold or flu?
    a) Yes
    b) No
    c) Maybe

11. In your opinion, are antibiotics effective against viral infections?
    a) Yes
    b) No
    c) Sometimes
    d) Don’t know

12. In your opinion does the unnecessary use of antibiotics make them become ineffective?
    a) False
    b) True
    c) Possibly
    d) I don’t know

13. Have you heard of the term Antibiotic resistance?
    a) Yes
    b) No
    c) I don’t know

14. What is your level of concern regarding antibiotic resistance?
    a) very concerned
    b) not that concerned
    c) Never thought about it

15. Do you think that antibiotic resistance is a problem that you may have to deal with in this lifetime?
    a) Yes, quite possibly
    b) No, I wouldn’t think so
    c) No, but I think it will be a problem for the next generation
    d) I don’t know

16. In your opinion, what is the underlying concern associated with antibiotic resistance?
    a) My antibiotic fails to work, and the doctor will need to prescribe me a new one
b) I think it may result in sicker patients and longer hospital stays, until an effective antibiotic is given.
c) I think it may result in untreatable infections, with a higher numbers of fatalities

17. What is your level of concern about the use of antibiotics in animal feed?
   a) very concerned
   b) not that concerned
   c) Never thought about it

18. Do you think that antibiotics use in food producing animals can indirectly affect the treatment of bacterial infections in humans?
   a) Yes
   b) No
   c) I don’t know

19. Would you choose organic meat products over conventional meat products, if they were the same price? (Feel free to tick more than one answer, if preferable)
   a) Yes, for animal welfare reasons
   b) Yes, because I am concerned about the amount of antibiotics being used in food producing animals
   c) Yes, because I would consider organic meat a superior product
   d) No, I would select the conventional product
   e) I don’t know

20. How would you prioritise the following practices to reduce antimicrobial resistance: (1 the most, 5 the least)
   a) Investing in the research to develop new antibiotics to replace those that are ineffective
   b) Doctor only prescribing antibiotics when absolutely necessary
   c) More public awareness campaigns to explain antibiotic resistance
   d) More needs to be done to ensure that antibiotics are used appropriately in agriculture and only used to treat sick animals
   e) Assisting farmers to shift methods of food production that requires less or no antibiotics e.g. organic farming

21. How would you rate the availability of public awareness campaigns regarding the use of antibiotics and antibiotic resistance?
   a) Poor
   b) Good
   c) Never seen one

22. How would you trust to be informed about antibiotic resistance?
   a) GP
   b) Radio
   c) TV
   d) Newspapers
   e) Social Media
   f) Others (Please specify)