Risk factors for chloramphenicol resistance in *Escherichia coli* isolated from poultry meat in Biskra (Algeria)

Fatores de risco para resistência ao cloranfenicol em *Escherichia coli* isolada de carne de aves em Biskra (Argélia)

Factores de riesgo de resistencia al cloranfenicol en *Escherichia coli* aislada de carne de aves de corral en Biskra (Argelia)

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ABSTRACT
This study is conducted to identify risk factors related to chloramphenicol resistance of *Escherichia coli* isolated in poultry meat. Total of 134 *E. coli* strains were isolated from 159 different poultry meat samples in 10 butcher shops, between January 2018 and 30 July 2020. Tow predictor variables were categorical; Carcass/cut and Before/after COVID-19 appearance. Chloramphenicol resistant *E. coli* isolated from carcass packed at slaughterhouses or from poultry meats purchased before COVID-19 emergence were compared with those isolated from poultry cuts in butchers shops or from poultry meats purchased after COVID-19 appearance respectively. The Pearson's chi-squared tests ($\chi^2$), t-tests and Odds ratios (ORs) were calculated for all emerging associations. Binary logistic regression was used to assess risk factors associated with chloramphenicol *E. coli* resistance in poultry meat. The frequency of chloramphenicol-resistant *E. coli* isolates was found higher (47.5%) after COVID-19's emergence than before COVID-19 (20.21%), p-value $\leq 0.001$. The effect of COVID-19 emergence on *E. coli* chloramphenicol resistance being OR= 3.57 (95% CI 1.61-7.94). The frequency of chloramphenicol-resistant *E. coli* isolates in poultry cuts was found to be greater (30%) than in poultry carcass (5%), p-value $\leq 0.01$. Poultry cuts having an OR= 9.08 effect on *E. coli* chloramphenicol resistance (95% CI 1.17-70.43). The logistic regression revealed that *E. coli* strains isolated from poultry meat purchased after COVID-19 outbreak are 6.58 times more likely to be chloramphenicol resistant than *E. coli* strains isolated from poultry meat purchased before COVID-19 appearance. The excessive use of biocides during COVID-19 outbreak increased the probability of chloramphenicol *E. coli* resistance in poultry meat and the carcass packed beforehand at slaughterhouses decreases the probability of chloramphenicol resistance of *E. coli* in poultry meat, later at the butcher shops.

Keywords: poultry meat, antimicrobial resistance, biocides, COVID-19, *E. coli*, regression analysis

RESUMO
Este estudo foi realizado para identificar fatores de risco relacionados à resistência ao cloranfenicol de *Escherichia coli* isolada em carne de aves. Um total de 134 cepas de *E. coli* foram isoladas de 159 amostras diferentes de carne de aves em 10 açougues, entre janeiro de 2018 e 30 de julho de 2020. As variáveis preditoras de Tow foram categóricas; Carcaça/corte e Antes/depois do aparecimento da COVID-19. *A E. coli* resistente ao cloranfenicol isolada de carcaças embaladas em matadouros ou de carnes de aves compradas
It is predicted that by 2050, antibiotic resistance could kill more people than cancer, with an additional 10 million people per year worldwide dying due to antibiotic resistance, as indicated in the report by O'Neill (2016). Microbiological resistance is the presence of a genetically determined resistance mechanism (acquired or mutated), categorizing the pathogen as resistant or susceptible.
based on the application of a set cut-off in a phenotypic laboratory test (MacGowan and Macnaughton, 2017). Resistance genes can be transferred between bacteria by horizontal transfer involving three mechanisms: conjugation, transduction and transformation (Acar and Moulin, 2012).

Resistant bacteria in animals can be transferred to people usually through the consumption of food (Aidara-Kane, 2012). In the case of meat products, chicken, turkey, beef, pork, and resulting products are major vehicles for transmission (Morente et al., 2013). Antimicrobial resistance was higher in *Escherichia coli* isolated from retail poultry meat than those from ground beef or pork (Sheikh et al., 2012). According to the FAO statistics, poultry has became the most widely consumed meat worldwide (Guergueb et al., 2020). An increase in demand has put the farmer under continuous pressure to produce poultry in the shortest period of time with maximum output (Muaz et al., 2018). Currently, many antibiotics are used in the poultry industry either as growth promoters or for prevention, control and treatment purposes (Adzitey, 2015), but it can lead to the development of resistant bacteria (pathogens and/or commensals with resistance genes) according to Aidara-Kane (2012). Extensive use of antimicrobials in animal production comes as a cost: it promotes antimicrobial resistance that threatens both animal health and human health (Xiong et al., 2018). Antibiotic resistance persists in spite of the restricted use of several key antibiotics, which indicates that there are components governing the evolution, dissemination and perpetuation of these resistance systems, many of which are independent of antibiotic usage (Baker-Austin et al., 2006; Thomas IV et al., 2020).

Biocides (antiseptics, disinfectants and preservatives) have been employed for centuries (Wooldridge, 2012). For food safety purposes, disinfectants are used on surfaces for maintaining hygiene in stables, abattoirs, food industry premises and equipment, retail shops, etc., and applied to carcasses, products, etc (Cerf et al., 2010). One concern is that such intense usage of biocides could lead to increased bacterial resistance to a product and cross-resistance to unrelated antimicrobials including chemotherapeutic antibiotics (Maillard, 2018). Bacteria tolerant to a wide range of antimicrobial compounds (including biocides) are becoming more frequent in the food chain (Morente et al., 2013). The regular and persisting use of chemical disinfectants in community and public settings under the current circumstance (COVID-19) may bring unintended consequences; constant selective pressures exerted on microbiota not only can increase their tolerance to biocidal agents but their resistance to certain antibiotics (Chen et al., 2021).

A different approach to association studies has been taken by some researchers to investigate the causative role of biocide exposure resulting in antimicrobial resistance. The majority of these studies have used (in-vitro) laboratory strains exposed to sub-lethal concentrations of biocides...
(Donaghy et al., 2019). Under laboratory conditions, some low-level cross-resistance between didecyldimethylammonium chloride (DDDMAC), eugenol and thymol was observed with the *E. coli* gradient plate mutants, as well as reduced susceptibility to antibiotics, most notably chloramphenicol (Walsh et al., 2003).

This study is conducted to identify risk factors related to chloramphenicol resistance of *E. coli* isolated in poultry meat in the Algerian city Biskra, before and after COVID-19 emergence.

Chloramphenicol is a representative amphenicol antibiotic, was considered to be a promising broad-spectrum antibiotic effective in both human and veterinary medicine (Tao et al., 2012). However, it was banned in 1994 from use in any food-producing animals in the European Union. The main reason for this ban was protection of the consumer from potential adverse effects arising from chloramphenicol residues in carcasses of food animals (Schwarz et al., 2004). Chloramphenicol is not used also in Algerian poultry industries (MARD, 2018). As a result, there is no risk of antibiotic resistance associated to its usage in poultry farming, so the bias due to the confounding factor is minimized.

2 MATERIALS AND METHODS

Sample collection

The research included ten butcher shops in Biskra, northeastern Algeria, and was conducted from January 2018 to 30 July 2020. 159 different poultry meat samples were bought from the butcher shops. Bacteriological analysis was performed on all samples. Total of 134 *E. coli* strains were isolated from poultry meat samples following the FDA’s Bacteriological Analytical Manual (FDA, 2020). 94 *E. coli* strains were isolated from poultry meat samples which were bought from the ten butcher shops prior of the COVID-19 outbreak between 01 January 2018 to January 2020 and 40 *E. coli* strains were isolated from poultry meat samples which were bought from the same butcher’s shops (10 shops) after the appearance of the outbreak of COVID-19; between 15 June 2020 and 30 July 2020.

Isolation and identification of *E. coli*

According to the FDA’s Bacteriological Analytical Manual (FDA, 2020), three to six representative colonies (purple-red colonies that are 0.5 mm or larger in diameter and surrounded by zone of precipitated bile acids) in Violet Red Bile Lactose (VRBL) agar (Himedia, India), from plates of each sample were picked on MacConkey agar (Liofilchem, Italy), and transferred each to a tube of BGLB (Brilliant Green Bile Broth with Durham Tube), to confirm that the colonies are *E. coli*. After incubation period (24 and 48 h) at 35°C, bacteria from Durham tubes with BGLB were
examined for gas production. If gas-positive BGLB tube shows a pellicle, Gram stain were performed to ensure that gas production was not due to Gram-positive lactose-fermenting bacilli. Alternatively, confirmed tests were performed on positive (gas) tubes (TSIA: Acid/Acid, Gas Positive, H₂S Negative, Citrate: Negative, Urease: Negative, Indole: Positive). Finally API20E strips (Biomerieu, France), were used to confirm *E. coli*.

**Antimicrobial susceptibility testing of *E. coli***

Antibiotic susceptibility test of all identified isolates (n = 134) was done following disc diffusion method. The interpretations were done according to the EUCAST (European Committee on Antimicrobial Susceptibility Testing) guidelines of 2019 (CASFM and EUCAST, 2019) and 2020 (CASFM and EUCAST, 2020). The antimicrobial used is: chloramphenicol (C, 30 μg). Bacterial suspensions were spread on Mueller-Hinton agar. The antibiotic discs were incubated at 37°C for 18-24 hours. The clear zone diameters of inhibition were measured in millimeter (mm).

**Predictor variables**

In this study, tow predictor variables were categorical (Table 1).

<table>
<thead>
<tr>
<th>Predictor variable</th>
<th>Variable class</th>
<th>N (%) of <em>E. coli</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass/cut</td>
<td>Carcass packed at slaughterhouse</td>
<td>28 (17.19)</td>
</tr>
<tr>
<td></td>
<td>Cut in butcher shop</td>
<td>106 (82.81)</td>
</tr>
<tr>
<td>COVID-19</td>
<td>Before COVID-19 emergence</td>
<td>94 (70.15)</td>
</tr>
<tr>
<td></td>
<td>After COVID-19 emergence</td>
<td>40 (29.85)</td>
</tr>
</tbody>
</table>

**Statistical analysis**

Chloramphenicol resistant *E. coli* isolated from hole carcass packed at slaughterhouses or from poultry meats purchased before COVID-19 emergence were compared with those isolated from poultry cuts in butcher shops or from poultry meats purchased after COVID-19 appearance respectively. Clear zone size was presented as mean ± standard error mean (SEM). Boxplots were used to check the data distribution. The Pearson's chi-squared tests ($X^2$) for categorical variables, and t-tests for continuous variables were used for univariate analysis. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for all emerging associations (risk factors). Multivariate analysis was used to assess the risk factors, and also to identify independent predictors by applying binary logistic regression. The area under the curve (AUC) was calculated using a receiver operating characteristic (ROC), Hosmer-Lemeshow test and Nagelkerke were determined for the goodness-of-fit of logistic regression model. P-value ≤ 0.05 was considered statistically significant. Figures
were generated and statistical tests carried out using Statistical Package for the Social Sciences (SPSS, Version 21).

3 RESULTS

T-Test

An independent t-test (Table 2) showed a significant difference (t = 3.72, p-value ≤ 0.001) between means of diameter of growth inhibition zone for chloramphenicol in *E. coli* isolates before COVID-19 (23.01 ± 0.67 mm) and after COVID-19 appearance (18.27 ± 1.14 mm), indicating that *E. coli* isolated from poultry meat purchased after the emergence of COVID-19 were more resistant than those isolated before the emergence of COVID-19.

It showed also that *E. coli* isolated from poultry carcass packed in the abattoir produced significantly (t = 4.76, p-value ≤ 0.001) larger zones (25.68 ± 0.63 mm) than from poultry cuts in butcher shops did (21.12 ± 0.72 mm). Indicating that *E. coli* isolated from poultry cuts in butcher shops were more resistant than those isolated from poultry carcasses packed in the abattoir. This difference between means is well illustrated by a comparative boxplots (Fig.1).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Variable class</th>
<th>Mean ± SEM (mm)</th>
<th>SD (mm)</th>
<th>T</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>COVID-19</td>
<td>Before COVID-19 emergence</td>
<td>23.01 ± 0.67</td>
<td>6.52</td>
<td>3.72</td>
<td>≤ 0.001</td>
</tr>
<tr>
<td></td>
<td>After COVID-19 emergence</td>
<td>18.27 ± 1.14</td>
<td>7.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carcass/cut</td>
<td>Carcass packed at slaughterhouse</td>
<td>25.68 ± 0.63</td>
<td>2.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cut in butchr shop</td>
<td>21.12 ± 0.72</td>
<td>7.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SEM = Standard Error Mean
SD = Standard Deviation
t = Student’s t-test

Table 2. Results of t-test for equality of mean diameter chloramphenicol susceptibility inhibition zones in *E. coli* isolates.

Fig. 1. Boxplot of chloramphenicol resistance in *E. coli*, estimated from inhibitor zone deviations
Comparing distribution of diameter zone of resistance in chloramphenicol of *E. coli* isolated from whole carcass and poultry cuts before and after the COVID-19 emergence. The lower the inhibition zone sizes are on the y-axis, the more the chloramphenicol *E. coli* resistance is. The box-plots indicated the median value (the line within each box) and interquartile range (the upper and lower boundaries of each box), whiskers below and above each box presented the 10<sup>th</sup> and 90<sup>th</sup> percentiles.

**Chi-square test (X<sup>2</sup>) and Odds Ratio (OR)**

As shown in Fig.2, the frequency of chloramphenicol-resistant *E. coli* isolates was found higher (47.5%) after COVID-19's emergence than before COVID-19's emergence (20.21%). Table 3 reveals a significant association between chloramphenicol *E. coli* resistance and the emergence of COVID-19 (*P*-value≤0.001), with the effect of COVID-19 emergence on chloramphenicol *E. coli* resistance being OR= 3.57 (95% CI 1.61-7.94).

Fig.3 reveals that the frequency of chloramphenicol-resistant *E. coli* isolates in poultry cuts was found to be greater (30%) than in poultry carcass (5%). As Table 3 shows, there is a significant relationship between chloramphenicol *E. coli* resistance and poultry cuts (*p*-value = 0.012), with poultry cuts having an OR= 9.08 effect on chloramphenicol *E. coli* resistance (95% CI 1.17-70.43).

**Table 3. Results of Chi-Square Analysis (X<sup>2</sup>) on resistance chloramphenicol *E. coli* resistance**

<table>
<thead>
<tr>
<th>Variable</th>
<th>X&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Df</th>
<th>p-value</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Befor/After COVID-19</td>
<td>10.28</td>
<td>1</td>
<td>0.001</td>
<td>3.57</td>
<td>[1.61-7.94]</td>
</tr>
<tr>
<td>Carcass/Cut</td>
<td>6.26</td>
<td>1</td>
<td>0.012</td>
<td>9.08</td>
<td>[1.17-70.43]</td>
</tr>
</tbody>
</table>

X<sup>2</sup> = Chi-squared test  
OR = Odds Ratios  
Df = Degrees of freedom  
CI = Confidence Interval

Fig. 2. Frequency histogram of the chloramphenicol *E. coli* resistance before and after COVID-19 emergence
Logistic regression

To assess the risk factors associated with chloramphenicol E. coli resistance in poultry meat, binary logistic regression analysis was used. The Hosmer–Lemeshow test (p-value = 0.93) indicates that the numbers of E. coli strains resistant to chloramphenicol are not significantly different from those predicted by the model and that the overall model fit is good. Nagelkerke $R^2 = 0.29$, it means that the strength of association between E. coli resistant and risk factors was 29%. The area under the ROC curve (Fig.4) was: 75.3% (95% CI: 0.66-0.85; P-value ≤ 0.001) indicating that the model discriminates well. Table 4 shows the regression coefficients of the predictors B, the Wald statistic, and the p-values.

Table 4. Logistic regression analysis results for the risk factors associated with E. coli chloramphenicol resistant in poultry meat.

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>B</th>
<th>Wald</th>
<th>Significance</th>
<th>Exp (B)</th>
<th>95% CI for Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Before/After COVID-19</td>
<td>2.03</td>
<td>17.89</td>
<td>0.001</td>
<td>7.58</td>
<td>2.97</td>
</tr>
<tr>
<td>Carcass/cut</td>
<td>2.96</td>
<td>7.37</td>
<td>0.007</td>
<td>19.26</td>
<td>2.28</td>
</tr>
<tr>
<td>Constant</td>
<td>- 4.48</td>
<td>16.02</td>
<td>0.001</td>
<td>0.01</td>
<td>163.04</td>
</tr>
</tbody>
</table>

From the result of the logistic regression analysis (Table 4), after COVID-19 (OR 7.58, 95% CI: 2.97-19.38; p-value ≤0.001) and pieces of poultry cut (OR 19.26, 95% CI: 2.28-163.04; p-value=0.007) were observed to be significant to predict chloramphenicol resistance in E. coli isolated in poultry meat.

E. coli strains isolated from poultry meat purchased after COVID-19 emergence were 6.58 times more likely to be chloramphenicol resistant than E. coli strains isolated from poultry meat.
purchased before COVID-19 appearance did. And the probability of chloramphenicol resistance in \textit{E. coli} associated with poultry meat purchased after COVID-19 is 2.03 times more than those purchased before COVID-19.

\textit{E. coli} strains isolated from pieces of poultry cut were 18.26 times more likely to be chloramphenicol resistant than \textit{E. coli} strains isolated from carcass. And the probability of chloramphenicol resistance in \textit{E. coli} associated with poultry cut is 2.96 times more than those isolated from packed carcass.

The logistic regression model can then be written as follows:

\[
\text{Logit } P = -4.48 + 2.03 \text{ (After COVID-19)} + 2.96 \text{ (poultry cut)}
\]

![Fig. 4. Area under the ROC curve](image)

**Binary logistic evaluation by receiver operating characteristic (ROC)**

4 DISCUSSION

The present study was designed to determine the effect of the cut of poultry meat in butcher shops and the excessive use of biocides during COVID-19 on the chloramphenicol \textit{E. coli} resistance in poultry meat. According to MARD (2018), chloramphenicol is not used in the Algerian poultry production. So there is no risk of antibiotic resistance linked to its use in aviculture, which reduce the bias caused by the confounding factor.
Excessive use of biocides during COVID-19

The resistance to chloramphenicol level of *E. coli* in poultry meat isolated between 01 January 2018 and January 2019, prior to the emergence of COVID-19 in Algeria, found in this study was 20.21% (Figure 2), which is similar to the results found in Algeria by Benklaouz et al., (2020) who found a resistance level of 22.75% of *E. coli* isolated from poultry from January 2017 to March 2019.

In the current study, comparing means of diameter of growth inhibition zone for chloramphenicol in *E. coli* isolates before COVID-19 emergence with those after COVID-19 showed a significant difference (*t* = 3.72, *P*-value ≤ 0.001), as mentioned in Table 2. The results of this study indicate also that, after the COVID-19 outbreak, a significant increase up to 47.5% as shown in Figure 2 (*p*-value ≤ 0.001, Table 3) of the *E. coli* resistance to chloramphenicol level, and the Odds Ratio found was OR = 3.57 (95% CI 1.61-7.94, Table 3). From the binary logistic regression analysis we found that the *E. coli* strains isolated from poultry meat purchased after COVID-19 emergence are 6.58 times more likely to be chloramphenicol resistant than *E. coli* strains isolated from poultry meat purchased before COVID-19 appearance. And the probability of chloramphenicol resistance in *E. coli* associated with poultry meat purchased after COVID-19 is 2.03 times more than those purchased before COVID-19 (Table 4).

The observed increase in *E. coli* chloramphenicol resistance associated with poultry meat purchased after COVID-19 appearance could be attributed to the excessive use of biocides during this outbreak in Algeria. The Algerian government has issued many decrees with additional measures to prevent and combat the spread of the coronavirus (COVID-19), according to World Health Organization’s recommendations, which could explain these results. These procedures include making disinfectant solutions, particularly hydro-alcoholic gels, available to employees and consumers, as well as daily cleaning and disinfection of business premises (Decree, 2020). The Algeria Press Service stated, on March 21, 2020, that several companies in the public and private sectors of the sanitation, disinfection and personal hygiene products sector have doubled their production capacity with the spread of the corona virus (Covid-19) in Algeria. The production capacity of the public sector companies specialized in the production of disinfectants and personal hygiene products is 1000 units/day for disinfectant gel and liquid soap, 4000 liters/day for surface cleaners as well as 4500 units of bleach. This unit should increase its production capacity to 3000 units/day of disinfectant gel and liquid soap, 20000 liters of floor cleaner as well as 10000 bottles of bleach (APS, 2020).

As result of this the availability of disinfectant products, in Algeria post COVID-19, there was a significant decrease of 0.639 log10 CFU/g (P-value <0.001) in bacterial contamination of...
poultry meat (Guergueb et al., 2021). The excessive use of biocides during the COVID-19 outbreak may have increased the risk of *E. coli* resistance to chloramphenicol in poultry meat.

In accordance with the present results, previous studies have demonstrated in vitro that the increasing popularity of biocide-containing domestic cleaning products which, when used inappropriately, may provide sublethal exposure represents a real risk for the development of resistance and the promotion of cross-resistance to a range of antimicrobial agents (Braoudaki and Hilton, 2004). According to Kampf (2018), antibiotic resistance may occur after exposure of various Gram-negative species to sublethal concentrations of some biocidal agents such as benzalkonium chloride, chlorhexidine or triclosan (Kampf, 2018). Russell (2000), found a linkage between low-level resistance to triclosan and to antibiotics has been claimed to occur in *E. coli* (Russell, 2000). Soumet and his collaborator reported in 2016 that the extensive use of didecyl dimethyl ammonium chloride (DDAC) at sub-inhibitory concentrations may lead to the development of chloramphenicol-resistant in *E. coli isolated* from pig faeces and pork meat (Soumet et al., 2016).

**Carcass packed at slaughterhouse or cut in butcher shop**

Another important finding was that *E. coli* isolated in poultry cuts was found to be more resistant to chloramphenicol than those in poultry carcass (*p-value* ≤ 0.01) as shown in Table 2, Table 3 and in Figure 1 and Figure 3, with poultry cuts having an OR= 9.08 effect on chloramphenicol *E. coli* resistance (95% CI 1.17-70.43, Table 3). Logistic regression analysis revealed that *E. coli* strains isolated from pieces of poultry cut are 18.26 times more likely to be chloramphenicol resistant than *E. coli* strains isolated from carcass. And the probability of chloramphenicol resistance in *E. coli* associated with poultry cut is 2.96 times more than those isolated from packed carcass (Table 4).

A possible explanation for these results might be that, in these butcher shops, whole carcasses packaged beforehand at slaughterhouses are protected of potential cross-contamination with bacteria present in butcher shops, so there is no exchange of genetic antibiotic-resistance with *E. coli* strains in packed whole carcass. Animal products may contain antimicrobial resistant bacteria as a result of fecal contamination during slaughter. The environment, including humans, can also contaminate food. Such contamination can occur after the processing of food and then it is called later contamination (Florez-Cuadrado et al., 2018). A high occurrence of antibiotic-resistant *Salmonella* and *Listeria monocytogenes* isolated from chicken meat and their related processing environments (Abatcha, 2017). Packed poultry meat beforehand at slaughterhouses is protected of potential cross-resistance with bacteria present in butcher shops. During the processing of meat the bacteria from animal origins can contaminate other food items, the processing plant, or workers. On
the other hand, it is possible that resistant organisms are introduced from the outside, e.g. by food handlers into the production line (Morente et al., 2013). *E coli* has been known for ages to easily and frequently exchange genetic information through horizontal gene transfer with other related bacteria (Agyare et al., 2018). Mangalassary, (2019) reported that the primary function of a package is to protect the product, including prevention of recontamination of poultry meat and products from spoilage and pathogenic bacteria (Mangalassary, 2019).

### 5 CONCLUSIONS

The main goal of the current study was to determine risk factors associated with chloramphenicol resistance of *E. coli* in poultry meat purchased from butcher shops in Biskra.

One of the more significant findings to emerge from this study is that the excessive use of biocides during COVID-19 increased the probability of chloramphenicol *E. coli* resistance in poultry meat. *E. coli* strains isolated from poultry meat purchased after COVID-19 emergence are 6.58 times more likely to be chloramphenicol resistant than *E. coli* strains isolated from poultry meat purchased before COVID-19 appearance. And the probability of chloramphenicol resistance in *E. coli* associated with poultry meat purchased after COVID-19 is 2.03 times more than those purchased before COVID-19.

Another factor identified in this study is that the packaging of poultry meat at slaughterhouses decreases the probability of chloramphenicol resistance of *E. coli* in poultry meat, later at the butcher shops. *E. coli* strains isolated from pieces of poultry cut are 18.26 times more likely to be chloramphenicol resistant than *E. coli* strains isolated from carcass. And the probability of chloramphenicol resistant in *E. coli* associated with poultry cut is 2.96 times more than those isolated from packed carcass.

### CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest in the research.
REFERENCES


