Heterogeneous location of the *mcr-1* gene in Colistin-Resistant *Escherichia coli* strains of Human and Chicken Meat Origin

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mcr-1 has been found in several different genetic backgrounds and in strains isolated from several reservoirs

**Aim of the study**: characterization of the genetic environment of mcr-1 in colistin-resistant *E. coli* strains of human, food and (food-producing) animal origin isolated in Switzerland
Methods

- **mcr-1 carrying E. coli** isolated from:
  - Swiss human faeces (n=3)  
  - Swiss chicken caecum (n=2)  
  - Swiss calf caecum (n=1)  
  - Swiss chicken retail meat (n=1)  
  - Imported (GER) retail chicken meat (n=2)  

  monitoring at ZOBA, Bern, Switzerland

- Whole-genome (WGS) and whole-plasmid sequencing (WPS) with MinION (Oxford Nanopore); assembly with Canu followed by correction with mapped Illumina reads

- Plasmid-, resistance-, virulence gene-, and multilocus sequence-typing with the online PlasmidFinder, ResFinder, VirulenceFinder, and MLST Tool platforms, respectively (http://www.genomicepidemiology.org/)
# Incl2 plasmid

Colistin-resistant *mcr-1* positive *E. coli* isolate

<table>
<thead>
<tr>
<th>ID</th>
<th>Mcp0221</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation source</td>
<td>imported retail chicken meat (GER)</td>
</tr>
<tr>
<td>MLST</td>
<td>ST1175</td>
</tr>
<tr>
<td>Colistin MIC (Etest)</td>
<td>4 mg/L</td>
</tr>
<tr>
<td>Plasmids (PlasmidFinder)</td>
<td>Incl2</td>
</tr>
<tr>
<td><em>mcr-1</em> location</td>
<td>Incl2 plasmid (64 kb)</td>
</tr>
<tr>
<td>Resistance genes (ResFinder)</td>
<td>colistin</td>
</tr>
</tbody>
</table>
Incl2 plasmid
# IncX4 plasmids

## Colistin-resistant *mcr-1* positive *E. coli* isolates

<table>
<thead>
<tr>
<th>ID</th>
<th>31349</th>
<th>Mcp0271</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation source</td>
<td>human faeces, HIV+ (CH)</td>
<td>imported retail chicken meat (GER)</td>
</tr>
<tr>
<td>MLST</td>
<td>ST5</td>
<td>ST58</td>
</tr>
<tr>
<td>Colistin MIC (Etest)</td>
<td>3 mg/L</td>
<td>4 mg/L</td>
</tr>
<tr>
<td>Plasmids (PlasmidFinder)</td>
<td>IncX4, IncL/M, IncFII and FIB</td>
<td>IncX4, IncFII/FIB/FIA,</td>
</tr>
<tr>
<td><em>mcr-1</em> location</td>
<td>IncX4 plasmid (33 kb)</td>
<td>IncX4 plasmid (33 kb)</td>
</tr>
<tr>
<td>Resistance genes (ResFinder)</td>
<td>colistin (<em>mcr-1.2</em>)</td>
<td>colistin (<em>β-lactams</em>)</td>
</tr>
<tr>
<td>Virulence genes (VirulenceFinder)</td>
<td><em>espA, espJ, eae, tir, cif, sepA, nleB</em> (=indicative for EPEC)</td>
<td></td>
</tr>
</tbody>
</table>
IncX4 plasmids

pMcp0271
chicken
meat (CH/D)
33 kb
ST58

p31349
human (CH)
33 kb
ST5

pMCR1.2-IT
(human (I))
33 kb
Kp ST512

mcr-1
pap2
pir

mcr-1.2
## IncHI2 plasmids

**Colistin-resistant mcr-1 positive E. coli isolates**

<table>
<thead>
<tr>
<th>ID</th>
<th>19-M12</th>
<th>100-R</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Isolation source</strong></td>
<td>human faeces, traveler to India (CH)</td>
<td>human faeces, traveler to India (CH)</td>
</tr>
<tr>
<td><strong>MLST</strong></td>
<td>ST5</td>
<td>ST10</td>
</tr>
<tr>
<td><strong>Colistin MIC (Etest)</strong></td>
<td>6 mg/L</td>
<td>12 mg/L</td>
</tr>
<tr>
<td><strong>Plasmids (PlasmidFinder)</strong></td>
<td>IncHI2, IncFII/FIB</td>
<td>IncHI2, IncFII, IncFIB, IncX1</td>
</tr>
<tr>
<td><strong>mcr-1 location</strong></td>
<td>IncHI2 plasmid (230 kb)</td>
<td>IncHI2 plasmid (250 kb)</td>
</tr>
<tr>
<td><strong>Resistance genes (ResFinder)</strong></td>
<td>colistin, trimethoprim-sulfamethoxazole, tetracycline, β-lactams, aminoglycosides, sulfonamides, macrolides (chloramphenicol, quinolones)</td>
<td>colistin, trimethoprim-sulfamethoxazole, tetracycline, β-lactams, aminoglycosides, sulphonamides, macrolides, chloramphenicol (quinolones)</td>
</tr>
</tbody>
</table>
IncHI2 plasmids

**p100R**
- Human (CH)
- 256 kb
- ST10

**p19-M12**
- Human (CH)
- 232 kb
- ST5

**pSA26-mcr1**
- Human (KSA)
- 240kb
- ST68

**p538**
- Poultry
- 248kb
- ST602

**p100R**
- repA
- tra locus
- mcr
- Δpap2
- ISapl1
- Δtra locus
- trhY
- trhR

**p19-M12**
- xerD
- ybaK
- ISapl1
- mcr
- Δpap2
- ISapl1
# IncK2 plasmids

Colistin-resistant *mcr-1* positive *E. coli* isolates

<table>
<thead>
<tr>
<th>ID</th>
<th>Mbl488</th>
<th>Mbl536</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation source</td>
<td>retail chicken meat (CH)</td>
<td>chicken caecum (CH)</td>
</tr>
<tr>
<td>MLST</td>
<td>ST38</td>
<td>ST226</td>
</tr>
<tr>
<td>Colistin MIC (Etest)</td>
<td>8 mg/L</td>
<td>4 mg/L</td>
</tr>
<tr>
<td>Plasmids (PlasmidFinder)</td>
<td>IncK2, IncFII/FIB, IncI2</td>
<td>IncK2, IncI1, IncX1</td>
</tr>
<tr>
<td><em>mcr-1</em> location</td>
<td>IncK2 plasmid (100 kb)</td>
<td>IncK2 plasmid (100 kb)</td>
</tr>
<tr>
<td>Resistance genes (ResFinder)</td>
<td>colistin, β-lactams (*bla&lt;sub&gt;CTX-M-1&lt;/sub&gt;), sulfonamides (<em>aminoglycosides</em>, <em>tetracycline</em>, <em>trimethoprim-sulfamethoxazole</em>)</td>
<td>colistin, β-lactams, sulfonamides (<em>tetracycline</em>, <em>trimethoprim-sulfamethoxazole</em>)</td>
</tr>
</tbody>
</table>
IncK2 plasmids

pMbl536
chicken caecum (CH)
100 kb
ST226

pMbl488
chicken meat (CH)
101 kb
ST38

pDV45
(KR905384)
poultry meat (CH)
86 kb
ST38

pndC  ISAp1  mcr-1  pap2  excA  traI
### Chromosomal location

Colistin-resistant *mcr-1* positive *E. coli* isolates

<table>
<thead>
<tr>
<th>ID</th>
<th>Mbl323</th>
<th>Mbl506</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation source</td>
<td>chicken caecum (CH)</td>
<td>calf caecum (CH)</td>
</tr>
<tr>
<td>MLST</td>
<td>ST38</td>
<td>ST1049</td>
</tr>
<tr>
<td>Colistin MIC (Etest)</td>
<td>8 mg/L</td>
<td>8 mg/L</td>
</tr>
<tr>
<td>Plasmids (Plasmidfinder)</td>
<td>IncK2 <em>(blaCMY-2)</em>, IncFII/FIB, IncN and ColRNAI</td>
<td>IncFII/FIB, Incl1, Incl2, IncQ1</td>
</tr>
<tr>
<td><em>mcr-1</em> location</td>
<td>chromosomal <em>(1 copy)</em></td>
<td>chromosomal <em>(2 copies, in different loci)</em></td>
</tr>
<tr>
<td>Resistance genes (Resfinder)</td>
<td>colistin <em>(β-lactams, aminoglycosides, lincosamides)</em></td>
<td>colistin <em>(β-lactams, tetracycline, aminoglycosides, macrolides, sulfonamides, trimethoprim-sulfamethoxazole)</em></td>
</tr>
</tbody>
</table>
Chromosomal location

A

Mbl323
cell
caecum (CH)
ST38

B

Mbl506
calf
caecum (CH)
ST1049

D5
(CP01045)
dog (China)
ST58
Conclusions

- *mcr-1* location highly heterogeneous
  - various plasmid types or integrated in different chromosomal loci

- IncI2, IncX4 and IncHI2 plasmids were highly similar to others previously described
  - common ecological niches worldwide

- Novel IncK2 plasmids found in both Swiss chicken caecum and retail meat
  - local spread of such *mcr-1*-carrying elements

- *mcr-1* found in MDR plasmids
  - even if colistin use in food-producing animals is restricted, other drugs (e.g., sulfonamides) may still select for colistin resistance
THANK YOU!

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