

# Resistencia a antibióticos desde la perspectiva One Health. El caso de *S. aureus* resistente a meticilina (SARM)



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**Universidad de La Rioja**

**León, 20 Octubre 2022**

# SARM desde la perspectiva One Health

- Prevalencia y epidemiología
- SARM en la interfaz animal-hombre

SARM-AG del linaje CC398

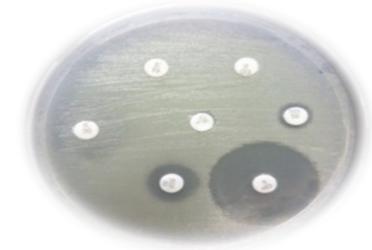
Humanos, animales, alimentos y ambiente

- Aspectos finales



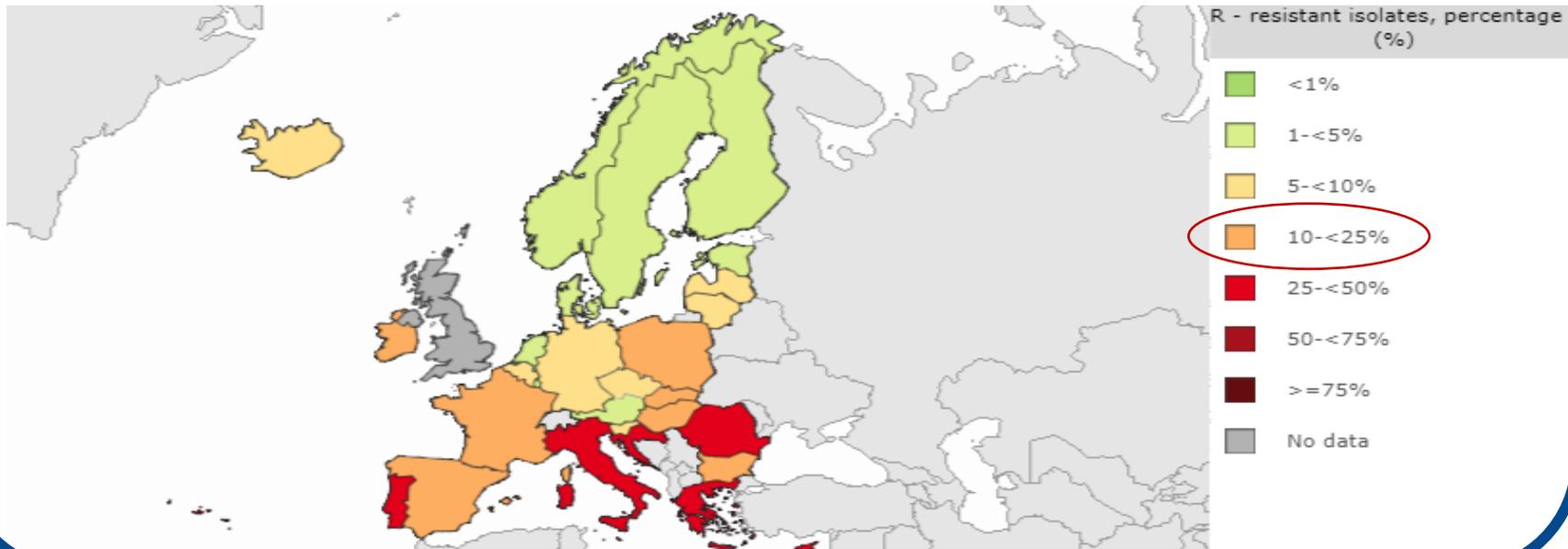
# *S. aureus*

- Comensal en humanos y animals (nariz, piel...)
- Patógeno oportunista



## SARM de especial relevancia

### Prevalencia de SARM en infecciones humanas invasivas (ECDC, 2020)



**Patrón  
Norte-Sur**



Colonización nasal  
en población sana



*S. aureus* 1/3

SARM <1%



Colonización con frecuencia precede a infección



# Epidemiología de SARM

## Emergencia de SARM-AG

CC5, CC22, CC36, CC45, CC247

**SARM-HA**



**1990' SARM-CA**

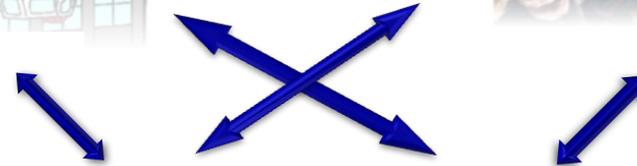


CC1, CC8, CC30  
CC59, CC80



**CC398**

**2005 SARM-AG**



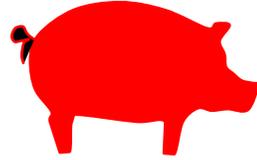
# Características de SARM-AG Linaje CC398

- MLST ST398 (CC398)
- *spa* t011, t034, t108 ....
- MDR: genes de resistencia nuevos o atípicos (Abs y metales)
  - *vga(C)*, *Inu(A)*, *Inu(B)*, *dfrK*... ; Cd, Zn
- Tet<sup>R</sup> (gen *tetM*)
- Poco virulentas (PVL negativo)
- Carecen del sistema IEC (adaptación al hombre)

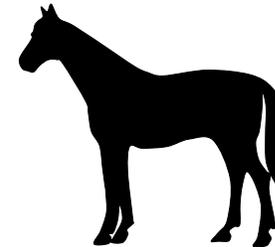
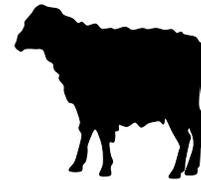
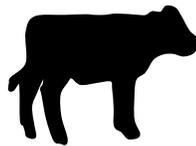


# SARM CC398

## En otras especies animales



- Vacas
- Pollos
- Perros
- Ratas
- Conejos
- Cabras
- Caballos
- Animales salvajes
- Animales zoo ... ..



# Colonización por SARM-CC398 en humanos sanos

## Nasal Colonization of Humans with Methicillin-Resistant *Staphylococcus aureus* (MRSA) CC398 with and without Exposure to Pigs

Christiane Cuny<sup>1</sup>, Rolf Nathaus<sup>2</sup>, Franziska Layer<sup>1</sup>, Birgit Strommenger<sup>1</sup>, Doris Altmann<sup>2</sup>, Wolfgang Witte<sup>1\*</sup>

**Veterinarios: 45%, relatives: 9%**  
**Ganaderos: 86%, relatives: 4%**

*Epidemiol. Infect.* (2010), 138, 756–763. © Cambridge University Press 2010  
doi:10.1017/S0950268810000245

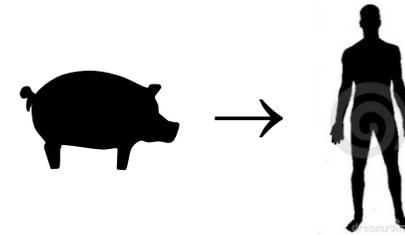
## High prevalence of nasal MRSA carriage in slaughterhouse workers in contact with live pigs in The Netherlands

**Mataderos: 0-22%**

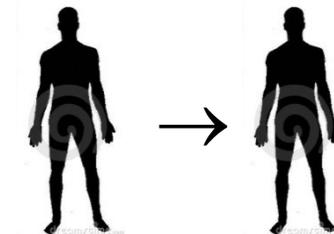
## Prevalence of methicillin-resistant *Staphylococcus aureus* among veterinarians: an international study

M. W. H. Wulf<sup>1</sup>, M. Sørum<sup>2</sup>, A. van Nes<sup>3</sup>, R. Skov<sup>2</sup>, W. J. G. Melchers<sup>1</sup>, C. H. W. Klaassen<sup>4</sup> and A. Voss<sup>1,4</sup>

**Veterinarios: 12%**



**Profesionales con riesgo**  
Contacto intenso con animales vivos



**Familiares**

# SARM CC398 en infecciones humanas

## Infecciones de piel

- Mastitis (Huijsdens, 2006)
- Endocarditis (Ekkelenkamp, 2006)
- Osteomielitis (Van Rijn, 2007)
- Infecciones de piel (Declercq, 2008)
- Primer brote CC398 en hospital (Wulf, 2008)



Generalmente en personas con contacto profesional

Aunque con escasa capacidad de transmission, también en personas sin contacto animal

# ST398 - Situación in España

## Grupo OneHealth-UR

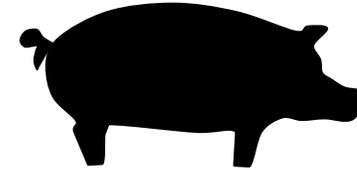


- Animales de producción  
- Alimentos 
- Animal-human transferencia   
- Casos clínicos humanos   Relación con densidad de granjas
- Animales de vida libre   
- Muestras ambientales (agua, aire)



# SARM-CC398 en cerdos en matadero

2008-2009



•Cerdos adultos  
**21%** SARM (71% CC398)

•Lechones  
**50%** SARM (100% CC398)

[Foodborne Pathog Dis.](#) 2010 Oct;7(10):1269-77. doi: 10.1089/fpd.2010.0610.

**Detection, molecular characterization, and clonal diversity of methicillin-resistant *Staphylococcus aureus* CC398 and CC97 in Spanish slaughter pigs of different age groups.**

[Gómez-Sanz E<sup>1</sup>](#), [Torres C](#), [Lozano C](#), [Fernández-Pérez R](#), [Aspiroz C](#), [Ruiz-Larrea F](#), [Zarazaga M](#).

# SARM-CC398 en infecciones humanas Primeros casos en España (2009-2011)

Pacientes: ganaderos porcino

Familiares y cerdos de granjas



Aragón: región con alta densidad de ganado porcino



Casos IPPB

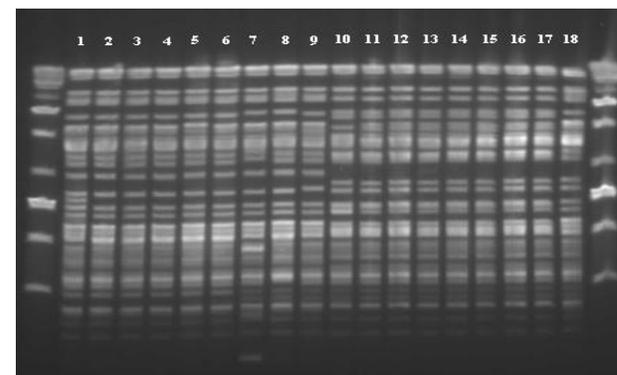


Caso severo  
EPOC

SARM CC398

- Baja virulencia
- Multi-resistencia (Tet<sup>R</sup>)
- Plasmidos con genes resistencia  
Antimicrobianos  
Metales

Posible transmisión  
animal-hombre



Pacientes-familiares-cerdos

RESEARCH ARTICLE

Open Access

Prevalence of colonization by methicillin-resistant *Staphylococcus aureus* ST398 in pigs and pig farm workers in an area of Catalonia, Spain



Esteban Reynaga<sup>1,2\*</sup>, Marian Navarro<sup>3</sup>, Anna Vilamala<sup>3</sup>, Pere Roure<sup>4</sup>, Manuel Quintana<sup>5</sup>, Marian Garcia-Nuñez<sup>6,7</sup>, Raúl Figueras<sup>8</sup>, Carmen Torres<sup>9</sup>, Gianni Lucchetti<sup>1</sup> and Miquel Sabrià<sup>2,6,7,10</sup>

# ¿SARM-CC398 en trabajadores de granjas?

Cerdos /ganaderos-porcino



Densidad ganado porcino



Osona

2014-15

83 ganaderos cerdos

20 granjas cerdos



140 ganaderos  
10 cerdos/granja

Colonización  
nasal

58% ganaderos  
45% cerdos



SARM  
CC398

19/20 similar ST398 cerdo/ganadero

RESEARCH ARTICLE

Open Access



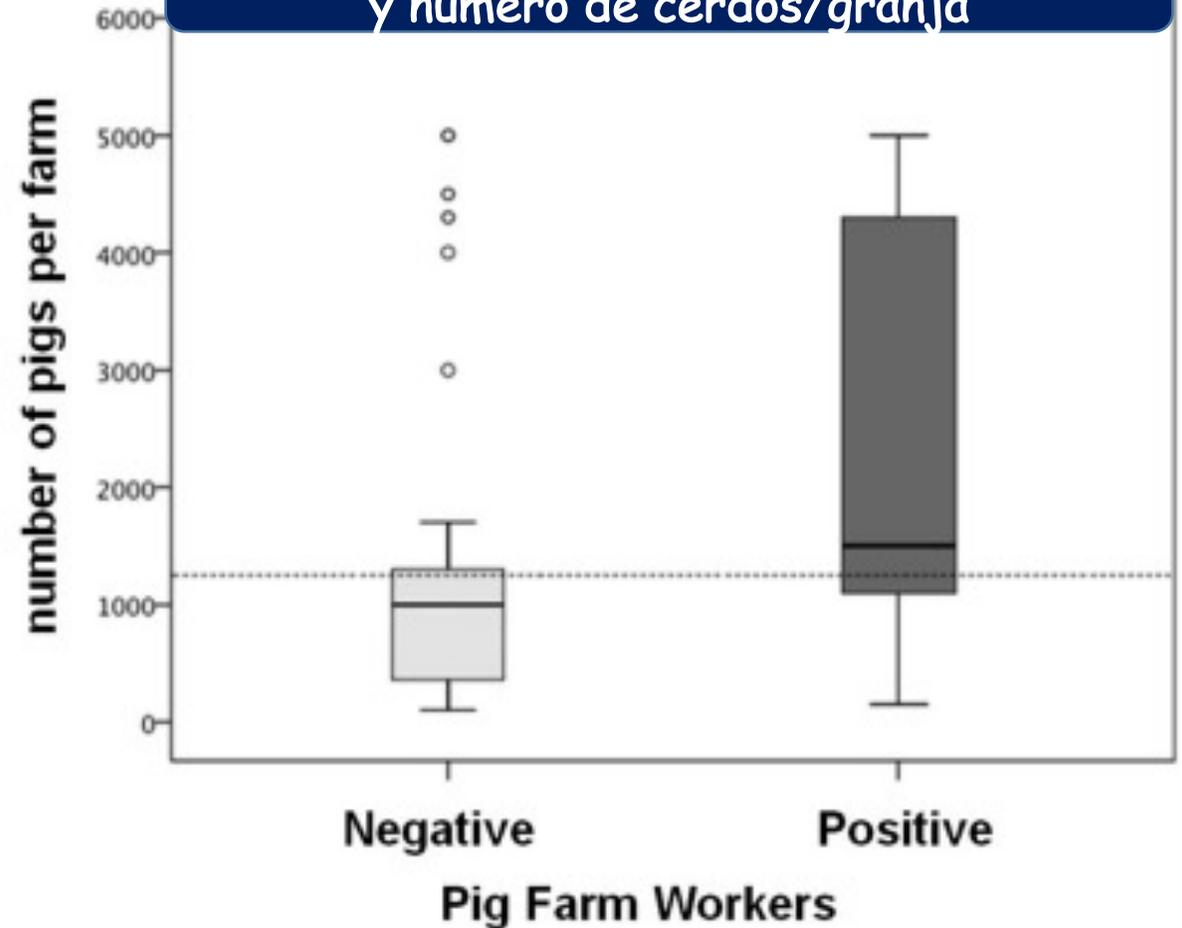
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## ¿SARM-CC398 en trabajadores de granjas?

### SARM-CC398 en ganaderos y número de cerdos/granja



RESEARCH ARTICLE

Open Access



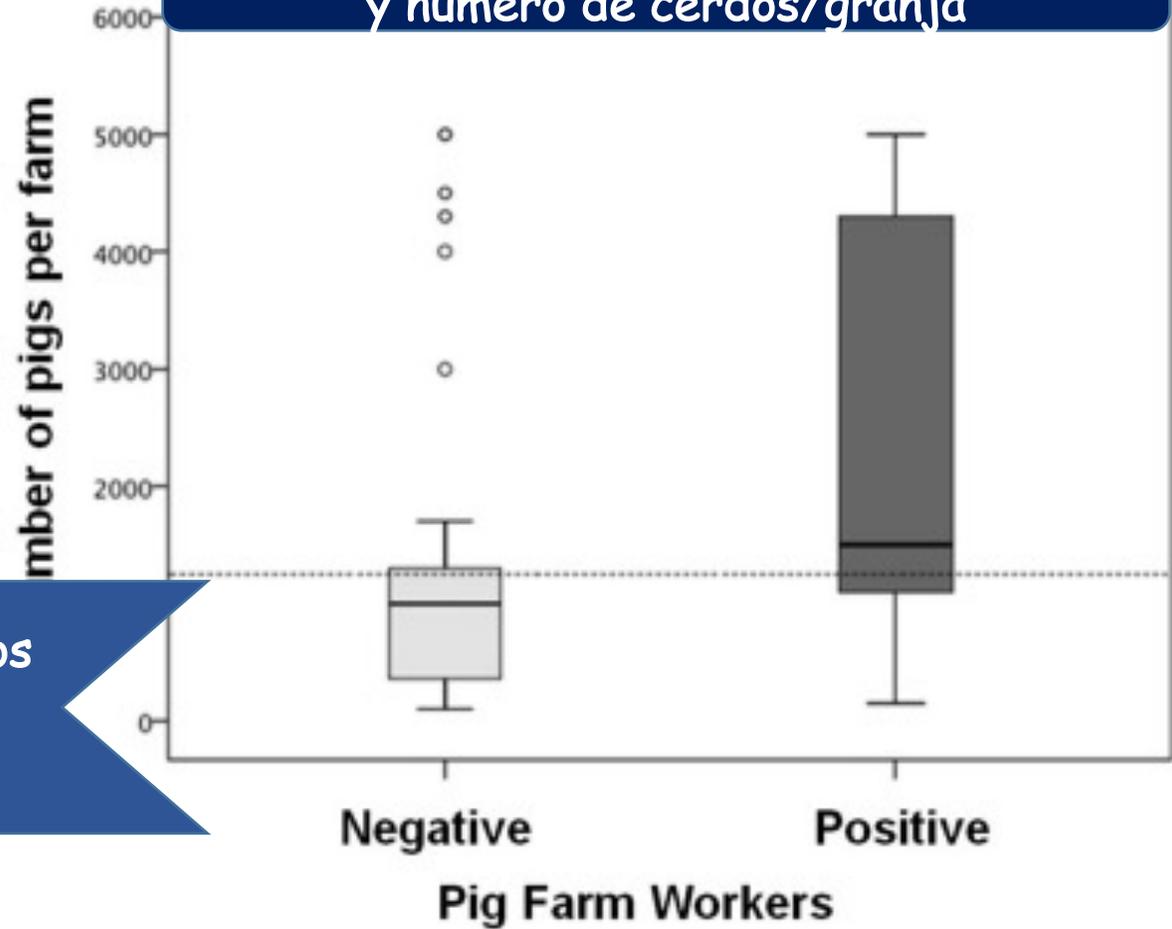
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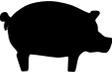
# ¿SARM-CC398 en trabajadores de granjas?

## SARM-CC398 en ganaderos y número de cerdos/granja



# ¿SARM-CC398 en cerdos y trabajadores de granjas? 2021-2022

## 4 Granjas de Aragón (alta densidad ganado porcino)

- 40 cerdos (10 por granja) 
- 10 trabajadores de las granjas 

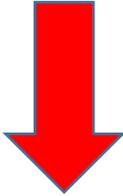
Colonización  
nasal

SARM CC398

4 granjas: humanos y cerdos con SARM-CC398  
>50%

# SARM-CC398 en derivados cárnicos de cerdo 2018

100 muestras  
17 establecimientos La Rioja



20%  
SARM  
CC398



Sin piel: 11%  
Con piel: 76%

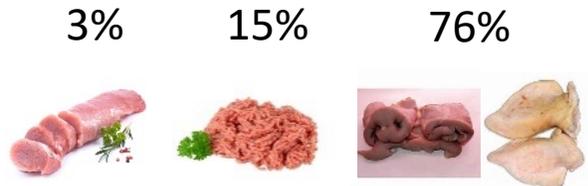
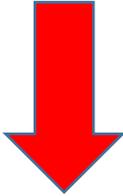


Table II: Molecular characteristics, antimicrobial resistance phenotype and virulence factors of MRSA and MSSA isolates

Species (N° isolates)	ST/CC (N° isolates)	spa-type (N° isolates)	Antimicrobial resistance phenotype <sup>a</sup> (N° isolates)	Virulence genes (N° isolates)	IEC type (N° isolates)
MRSA (21)	ST398/CC398 (19)	t011 (13)	PEN, FOX, TET, ERY, CLI (6)	<i>eta</i> (1)	-
			PEN, FOX, TET, CLI (4)	-	-
			PEN, FOX, TET, GEN, TOB, CLI (1)	-	-
			PEN, FOX, TET, CLOR (1)	-	-
		t1451 (2)	PEN, FOX, TET (1)	<i>eta</i>	B
		t1606 (2)	FOX, TET, ERY, CLI (1)	<i>tst</i>	-
			FOX, TET, CLI (1)	-	-
			PEN, FOX, TET, ERY, CLI, TOB, CLOR (1)	-	-
			PEN, FOX, TET, ERY, CLI, CLOR (1)	-	-
			PEN, FOX, TET, ERY, CLI	-	-
	t779 (1)	PEN, FOX, TET, GEN, TOB	-	-	
	t8151(2)	PEN, FOX (2)	<i>lukF/lukS-PV</i> (2)	-	
	ST8/CC8 (2)				
MSSA (19)	ST398/CC398 (7)	t011 (4)	PEN, TET (2)	-	-
			PEN, TET, ERY, CLI, CLOR (1)	-	-
			PEN, TET, ERY, CLI (1)	-	-
		t5452 (2)	PEN, ERY, CLI <sup>b</sup>	-	-
			PEN, ERY, CLI <sup>b</sup> , GEN	-	C
		t108 (1)	PEN, TET, ERY, CLOR	-	-
		t230 (2)	PEN (2)	-	B (2)
		t1939 (1)	PEN, TET, ERY, CLIN	-	-
		t4644 (1)	PEN	-	-
		t127	ERY, CLIN	-	-
		t701	PEN, TET	-	-
		t091	Susceptible	-	-
		t156	Susceptible	-	-
	t1862	Susceptible	-	-	
	t18461 <sup>c</sup>	Susceptible	<i>tst</i>	-	
	t18358 <sup>c</sup>	PEN, TET, ERY, CLI	-	-	
	t2247	PEN, TET, CLI, GEN, TOB	-	-	
	ST45/CC45 (2)				
	ST9/CC9 (2)				
	ST1/CC1(1)				
	ST6/CC6 (1)				
	ST7/CC7 (1)				
	ST12/CC12 (1)				
	ST22/CC22 (1)				
	ST133/CC133 (1)				
	ST581 (1)				
	ST692 (1)				

# SARM-CC398 en derivados cárnicos de cerdo 2018

100 muestras  
17 establecimientos La Rioja



20%  
SARM  
CC398



Sin piel: 11%  
Con piel: 76%



3%      15%      76%



Table II: Molecular characteristics, antimicrobial resistance phenotype and virulence factors of MRSA and MSSA isolates

Species (N° isolates)	ST/CC (N° isolates)	spa-type (N° isolates)	Antimicrobial resistance phenotype <sup>a</sup> (N° isolates)	Virulence genes (N° isolates)	IEC type (N° isolates)
MRSA (21)	ST398/CC398 (19)	t011 (13)	PEN, FOX, TET, ERY, CLI (6)	<i>eta</i> (1)	-
			PEN, FOX, TET, CLI (4)	-	-
			PEN, FOX, TET, GEN, TOB, CLI (1)	-	-
			PEN, FOX, TET, CLOR (1)	-	-
		t1451 (2)	PEN, FOX, TET (1)	<i>eta</i>	B
			FOX, TET, ERY, CLI (1)	<i>tst</i>	-
		t1606 (2)	FOX, TET, CLI (1)	-	-
			PEN, FOX, TET, ERY, CLI, TOB, CLOR (1)	-	-
		t4030 (1)	PEN, FOX, TET, ERY, CLI, CLOR (1)	-	-
		t779 (1)	PEN, FOX, TET, GEN, TOB	-	-
t8151(2)	PEN, FOX (2)	<i>lukF/lukS-PV</i> (2)	-		
MSSA (19)	ST8/CC8 (2)				
MSSA (19)	ST398/CC398 (7)	t011 (4)	PEN, TET (2)	-	-
			PEN, TET, ERY, CLI, CLOR (1)	-	-
			PEN, TET, ERY, CLI (1)	-	-
	t5452 (2)	PEN, ERY, CLI <sup>b</sup>	-	-	
		PEN, ERY, CLI <sup>b</sup> , GEN	-	C	
	t108 (1)	PEN, TET, ERY, CLOR	-	-	
	ST45/CC45 (2)	t230 (2)	PEN (2)	-	B (2)
	ST9/CC9 (2)	t1939 (1)	PEN, TET, ERY, CLIN	-	-
	ST1/CC1(1)	t4644 (1)	PEN	-	-
		t127	ERY, CLIN	-	-
	ST6/CC6 (1)	t701	PEN, TET	-	-
	ST7/CC7 (1)	t091	Susceptible	-	-
	ST12/CC12 (1)	t156	Susceptible	-	-
ST22/CC22 (1)	t1862	Susceptible	-	-	
ST133/CC133 (1)	t18461 <sup>c</sup>	Susceptible	<i>tst</i>	-	
ST581 (1)	t18358 <sup>c</sup>	PEN, TET, ERY, CLI	-	-	
ST692 (1)	t2247	PEN, TET, CLI, GEN, TOB	-	-	

# SARM-ST398 en carne de pollo 2021-2022

- Muestras de carne de pollo de mercados y supermercados de La Rioja



**3,3%**  
**SARM-CC398**  
**t1451**

**6,5%%**  
**SASM-CC398**  
**t1451**

# Tipo de carne y SARM-CC398

Foodborne Pathog Dis. 2015 Aug;12(8):686-92. doi: 10.1089/fpd.2015.1958. Epub 2015 Jun 18.

## Characterization of Staphylococcus aureus from Raw Meat Samples in Tunisia: Detection of Clonal Lineage ST398 from the African Continent.

Chairat S<sup>1</sup>, Gharsa H<sup>1</sup>, Lozano C<sup>2</sup>, Gómez-Sanz E<sup>2,3</sup>, Gómez P<sup>2</sup>, Zarazaga M<sup>2</sup>, Boudabous A<sup>1</sup>, Torres C<sup>2</sup>, Ben Slama K<sup>1,4</sup>.

Linaje genético  
t4358

SARM CC398  
t899



Primer  
SARM  
CC398 en  
Africa

Granjero  
de pollos

Hospital  
SARM CC398-t899



UNIVERSIDAD  
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OneHealth-UR

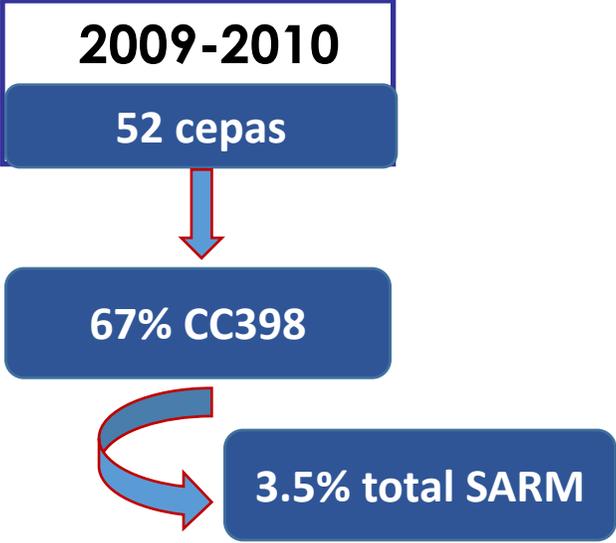
# Prevalencia de SARM-CC398 hospitales



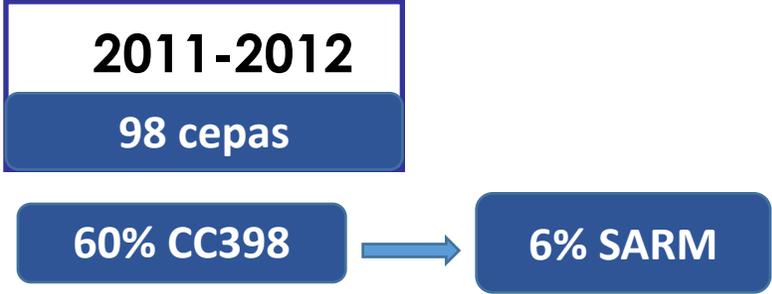
# SARM-CC398 en hospitales

Tet<sup>R</sup> → marcador de SARM-CC398

**SARM Tet<sup>R</sup>**



11%: fluidos estériles  
25-30%: colonización nasal



Lozano *et al*, JAC 2012

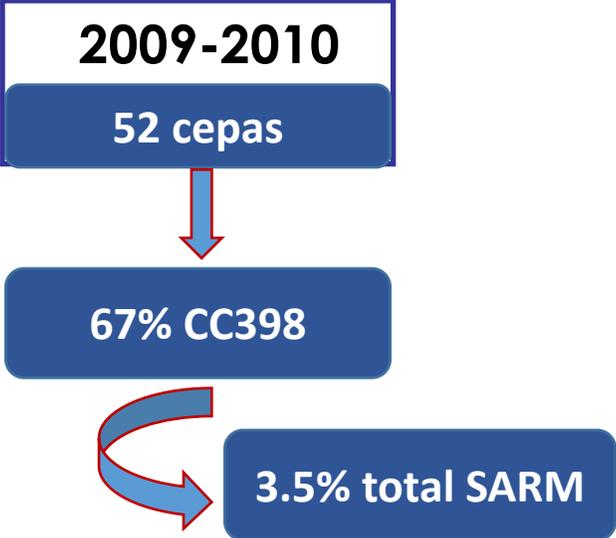
Benito *et al*, IJMM 2014



# SARM-CC398 en hospitales

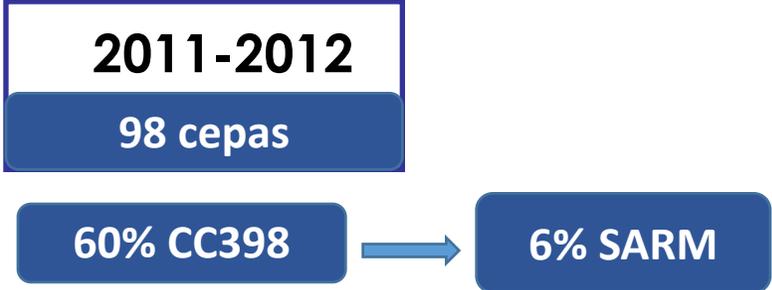
Tet<sup>R</sup> → marcador de SARM-CC398

**SARM Tet<sup>R</sup>**



11%: fluidos estériles  
25-30%: colonización nasal

Lozano *et al*, JAC 2012



¿El contacto con granjas es factor de riesgo de infección por SARM-ST398?

Factor de riesgo  
PERO  
Diseminación en población sin riesgo

Benito *et al*, IJMM 2014

Prevalencia de SARM-CC398 en Hospitales españoles  
**Densidad de Ganado Porcino (DGP)**  
¿Relación significativa?



**Estudio multicéntrico español**  
**20 hospitales (diferente DGP)**  
**SARM-Tet<sup>R</sup> (6 meses, 2016)**

*J Antimicrob Chemother* 2019; **74**: 2157–2161  
doi:10.1093/jac/dkz180 Advance Access publication 16 May 2019

**Journal of  
Antimicrobial  
Chemotherapy**

**Epidemiology of MRSA CC398 in hospitals located in Spanish regions  
with different pig-farming densities: a multicentre study**

Sara Ceballos<sup>1</sup>, Carmen Aspiroz<sup>2</sup>, Laura Ruiz-Ripa<sup>1</sup>, Esteban Reynaga<sup>3</sup>, José Manuel Azcona-Gutiérrez<sup>4</sup>,  
Antonio Rezusta<sup>5</sup>, Cristina Seral<sup>6</sup>, Fernando Antoñanzas<sup>7</sup>, Luis Torres<sup>8</sup>, Concepción López<sup>9</sup>,  
Lorena López-Cerero<sup>10</sup>, Emilia Cercenado<sup>11</sup>, Myriam Zarazaga<sup>1</sup> and Carmen Torres <sup>1\*</sup> on behalf of the Study  
Group of clinical LA-MRSA†

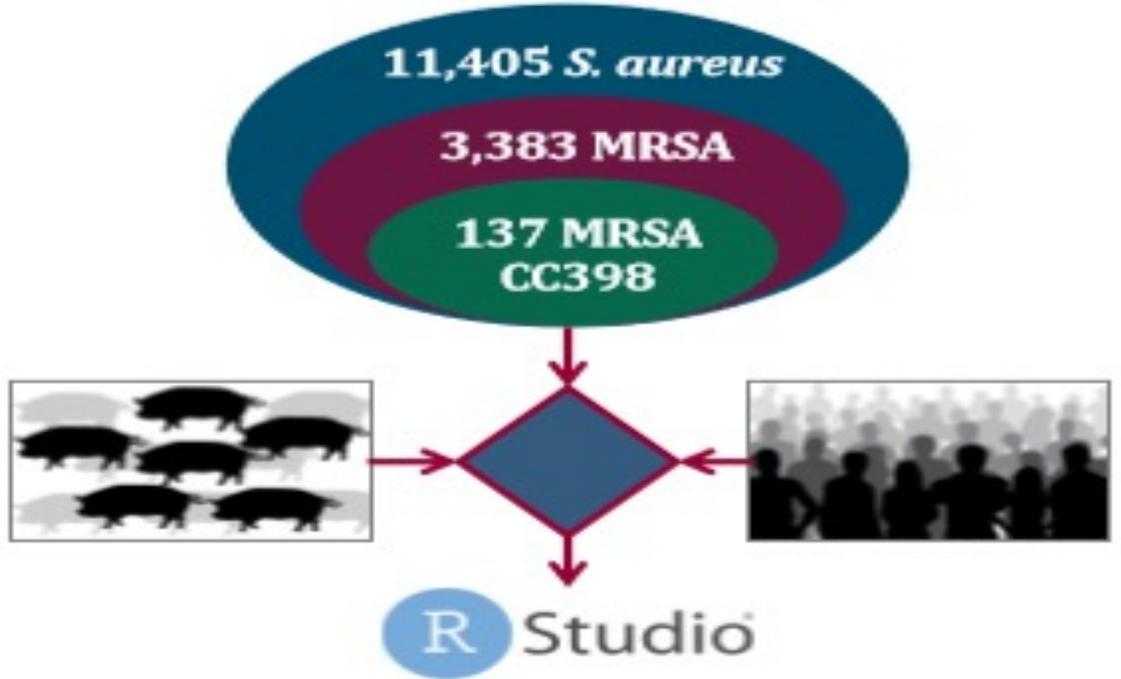
# SARM-CC398 en Hospitales españoles y densidad de ganado porcino (DGP) ¿Relación?

Journal of Antimicrobial Chemotherapy

J Antimicrob Chemother 2019; 74: 2157-2161  
doi:10.1093/jac/dkz180 Advance Access publication 16 May 2019

## Epidemiology of MRSA CC398 in hospitals located in Spanish regions with different pig-farming densities: a multicentre study

Sara Ceballos<sup>1</sup>, Carmen Aspiroz<sup>2</sup>, Laura Ruiz-Ripa<sup>1</sup>, Esteban Reynaga<sup>3</sup>, José Manuel Azcona-Gutiérrez<sup>4</sup>, Antonio Rezusta<sup>5</sup>, Cristina Seral<sup>6</sup>, Fernando Antoñanzas<sup>7</sup>, Luis Torres<sup>8</sup>, Concepción López<sup>9</sup>, Lorena López-Cerero<sup>10</sup>, Emilia Cercenado<sup>11</sup>, Myriam Zarazaga<sup>1</sup> and Carmen Torres<sup>1\*</sup> on behalf of the Study Group of clinical LA-MRSA†



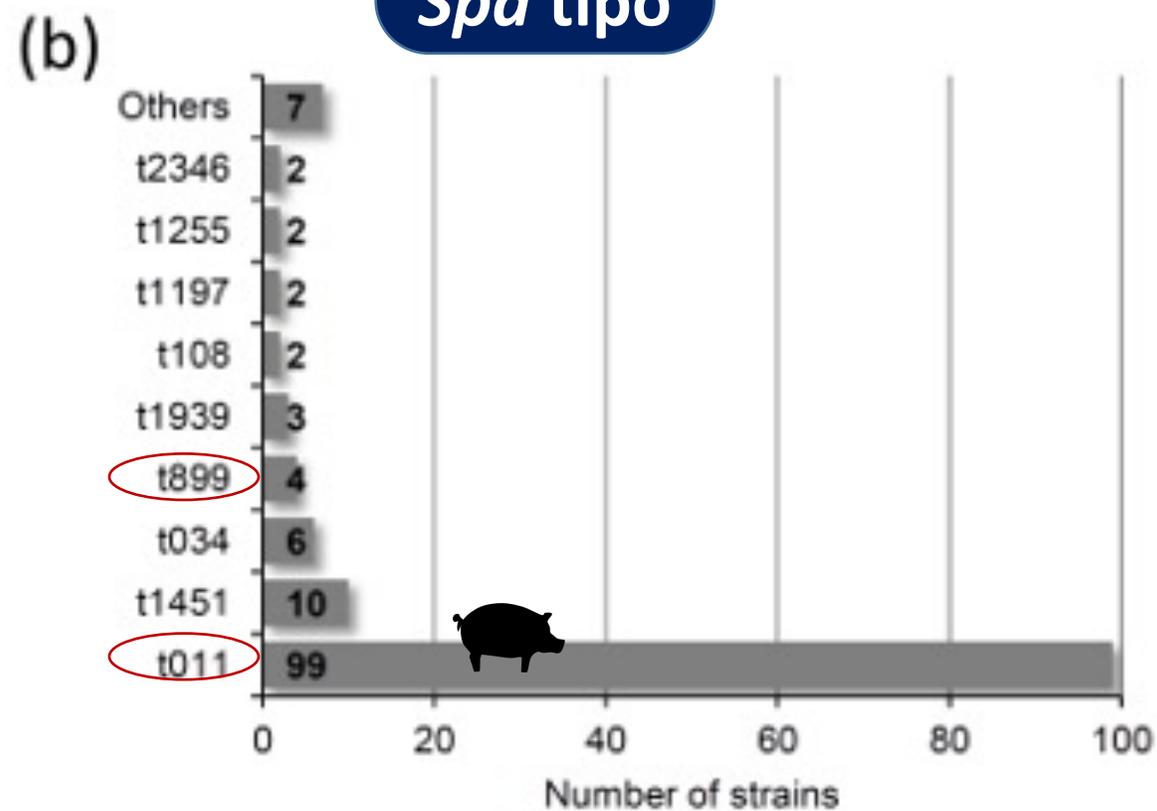
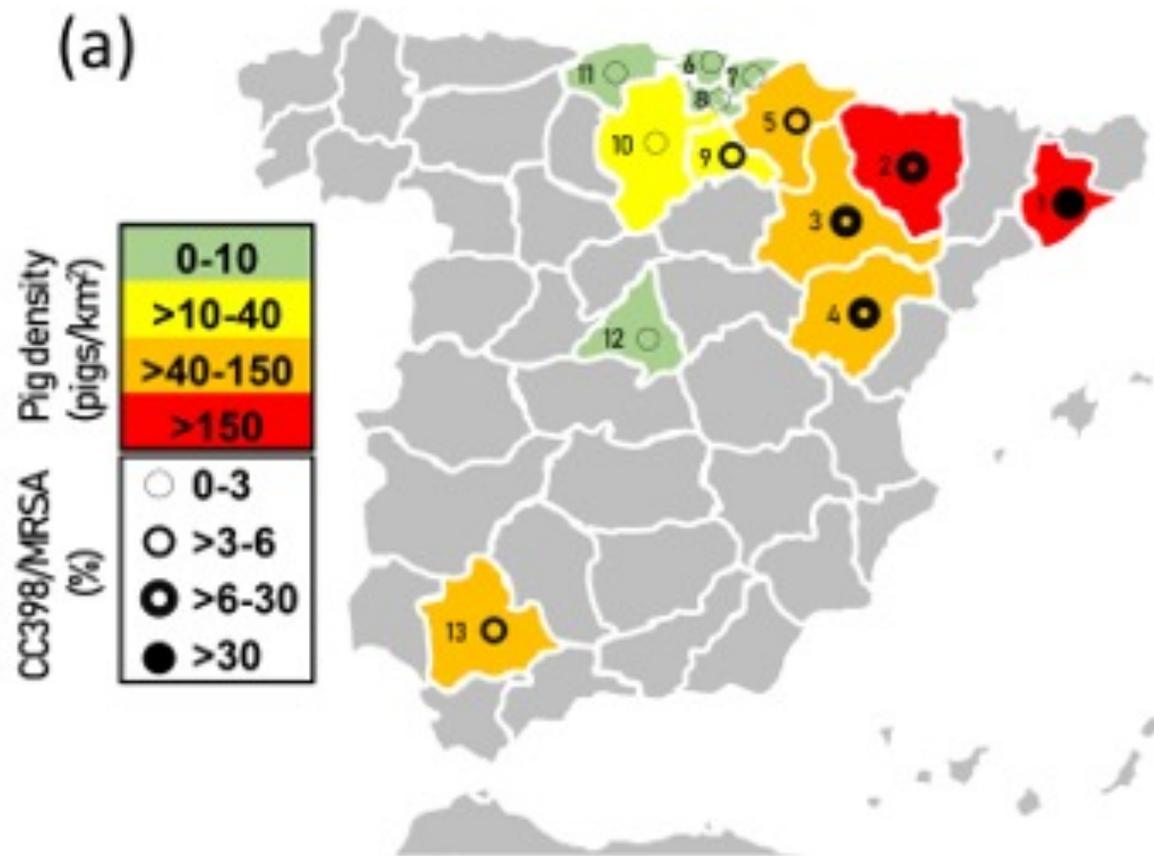
## Relationship: MRSA-CC398 in hospitals and PDF of the region

Hospital number	Hospital	Region	<i>S. aureus</i>	MRSA	Tet <sup>R</sup> -MRSA	MRSA-CC398	% MRSA-CC398/ MRSA	Pig density per region (pigs/km <sup>2</sup> )	Population density per region (habitants/km <sup>2</sup> )
H1	Hospital Universitari de Vic	Barcelona	122	87	33	27	31%	247.46	717.36
H2	Hospital de Barbastro	Huesca	341	135	20	19	14.1%	217.68	14.05
H3	Hospital San Jorge	Huesca	575	328	24	15	4.6%	217.68	14.05
H4	Hospital Miguel Servet	Zaragoza	1024	251	34	18	7.2%	142.66	55.20
H5	Hospital Lozano Blesa	Zaragoza	670	175	20	9	5.1%	142.66	55.20
H6	Hospital Royo Villanova	Zaragoza	180	76	9	7	9.2%	142.66	55.20
H7	Hospital Ernest Lluch Martin	Zaragoza	126	42	6	3	7.1%	142.66	55.20
H8	Hospital de Alcañiz	Teruel	99	36	4	4	11.1%	69.97	9.15
H9	Clínica Universitaria de Navarra	Navarra	304	36	2	2	5.6%	50.89	61.90
H10	Complejo Hospitalario de Navarra	Navarra	799	206	14	7	3.4%	50.89	61.90
H11	Hospital Virgen Macarena	Sevilla	250	84	7	3	3.6%	42.10	138.18
H12	Hospital Universitario de Burgos	Burgos	666	220	6	3	1.4%	27.66	25.54
H13	Hospital Santiago Apóstol	Burgos	113	42	2	0	0%	27.66	25.54
H14	Hospital San Pedro	La Rioja	368	112	6	4	3.6%	18.31	62.51
H15	Hospital Universitario de Álava	Álava	978	334	5	5	1.5%	4.99	107.53
H16	Hospital Universitario de Donostia	Gipuzkoa	1009	130	7	3	2.3%	3.56	360.18
H17	Hospital Gregorio Marañón	Madrid	1480	315	12	0	0%	2.85	810.66
H18	Hospital de Galdakao	Bizkaia	762	277	7	3	1.1%	2.19	517.95
H19	Hospital Marqués de Valdecilla	Cantabria	1124	371	13	5	1.3%	0.45	109.06
H20	Hospital Sierrallana	Cantabria	415	126	1	0	0%	0.45	109.06
TOTAL			11405	3383	232	137	31% - 0%	247-0.4	

## Epidemiology of MRSA CC398 in hospitals located in Spanish regions with different pig-farming densities: a multicentre study

Sara Ceballos<sup>1</sup>, Carmen Aspiroz<sup>2</sup>, Laura Ruiz-Ripa<sup>1</sup>, Esteban Reynaga<sup>3</sup>, José Manuel Azcona-Gutiérrez<sup>4</sup>, Antonio Rezusta<sup>5</sup>, Cristina Seral<sup>6</sup>, Fernando Antoñanzas<sup>7</sup>, Luis Torres<sup>8</sup>, Concepción López<sup>9</sup>, Lorena López-Cerero<sup>10</sup>, Emilia Cercenado<sup>11</sup>, Myriam Zarazaga<sup>1</sup> and Carmen Torres<sup>1\*</sup> on behalf of the Study Group of clinical LA-MRSA†

20 hospitales  
13 regiones  
9 CCAA



IEC negativo: > 95%

SARM-AG

**Table 2.** Correlation and linear regression results between MRSA CC398 cases and pig or human population densities.

Variables	Spearman correlations	Linear regression models	
	rho (p)	R <sup>2</sup> (F value; p)	β (t value; p)
MRSA CC398/ MRSA <sup>a</sup> pigs/ km <sup>2</sup> <sup>b</sup>	ρ=0.86 (p<0.001)	R <sup>2</sup> =0.58 (F=25.21; p<0.001)	β <sub>0</sub> =5.5853e-03 (t=0.38; p=0.71) β <sub>1</sub> =6.553e-04 (t=5.02; p<0.001)
MRSA CC398/ MRSA <sup>a</sup> habitants/ km <sup>2</sup> <sup>b</sup>	ρ=-0.39 (p=0.09)	R <sup>2</sup> =0.06 (F=1.23; p=0.28)	β <sub>0</sub> =4.387e-02 (t=2.25; p=0.03) β <sub>1</sub> =7.535e-05 (t=1.11; p=0.28)
MRSA CC398/ <i>S. aureus</i> <sup>a</sup> pigs/ km <sup>2</sup> <sup>b</sup>	ρ=0.89 (p<0.001)	R <sup>2</sup> =0.46 (F=15.22; p=0.001)	β <sub>0</sub> =-6.0893e-03 (t=-0.53; p=0.60) β <sub>1</sub> =3.978e-04 (t=3.90; p=0.001)
MRSA CC398/ <i>S. aureus</i> <sup>a</sup> habitants/ km <sup>2</sup> <sup>b</sup>	ρ=-0.45 (p=0.05)	R <sup>2</sup> =0.16 (F=3.51; p=0.08)	β <sub>0</sub> =1.100e-02 (t=0.87; p=0.39) β <sub>1</sub> =8.233e-05 (t=1.87; p=0.08)
MRSA CC398/ MRSA <sup>a</sup> pigs/ km <sup>2</sup> <sup>b</sup> habitants/ km <sup>2</sup> <sup>b</sup>	-	R <sup>2</sup> =0.68 (F=17.86; p<0.001)	β <sub>0</sub> =-1.122e-02 (t=-0.74; p=0.47) β <sub>1</sub> =6.735e-04 (t=5.69; p<0.001) β <sub>2</sub> =9.146e-05 (t=2.23; p=0.04)
MRSA CC398/ <i>S. aureus</i> <sup>a</sup> pigs/ km <sup>2</sup> <sup>b</sup> habitants/ km <sup>2</sup> <sup>b</sup>	-	R <sup>2</sup> =0.66 (F=16.67; p<0.001)	β <sub>0</sub> =-2.305e-02 (t=-2.16; p=0.05) β <sub>1</sub> =4.162e-04 (t=5.01; p<0.001) β <sub>2</sub> =9.229e-05 (t=3.21; p=0.01)

**FORMULA 1**

$$\text{Dependent variable} = \beta_0 + (\beta_1 \cdot \text{pigs/ km}^2)$$

models

**FORMULA 2**

$$\text{Dependent variable} = \beta_0 + (\beta_1 \cdot \text{pigs/ km}^2) + (\beta_2 \cdot \text{habitants/ km}^2)$$



# Prevalencia de SARM-CC398 Ambiente natural

# SARM CC398 en Plantas Tratamiento de Aguas Residuales (EDAR)

Environmental Pollution 212 (2016) 71–76



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Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: [www.elsevier.com/locate/envpol](http://www.elsevier.com/locate/envpol)



Characterization of staphylococci in urban wastewater treatment plants in Spain, with detection of methicillin resistant *Staphylococcus aureus* ST398<sup>☆</sup>



Paula Gómez, Carmen Lozano, Daniel Benito, Vanesa Estepa, Carmen Tenorio, Myriam Zarazaga, Carmen Torres<sup>\*</sup>

Department of Food and Agriculture, University of La Rioja, Logroño, Spain

Characteristics and origin of the eight *S. aureus* strains included in this study.

Strain	UWTP sample <sup>a</sup>	Molecular typing				IEC <sup>c</sup>
		<i>spa</i>	<i>agr</i>	ST	CC	
C6857	C-E	t011	II	ST398	CC398	
C6872	AN-I	t002	II		CC5	Type F
C6853	A-E	t002	II	ST5	CC5	Type F
C6884	C-E	t3262	II	ST5	CC5	Type F
C6856	C-I	t605	II	ST126	CC126	
C6862	L-I	t605	II		CC126	
C6889	L-E	t605	II		CC126	
C6865	L-E	t878	III	ST2849 <sup>b</sup>	CC779	<i>sak-chp</i>

SARM

efluente

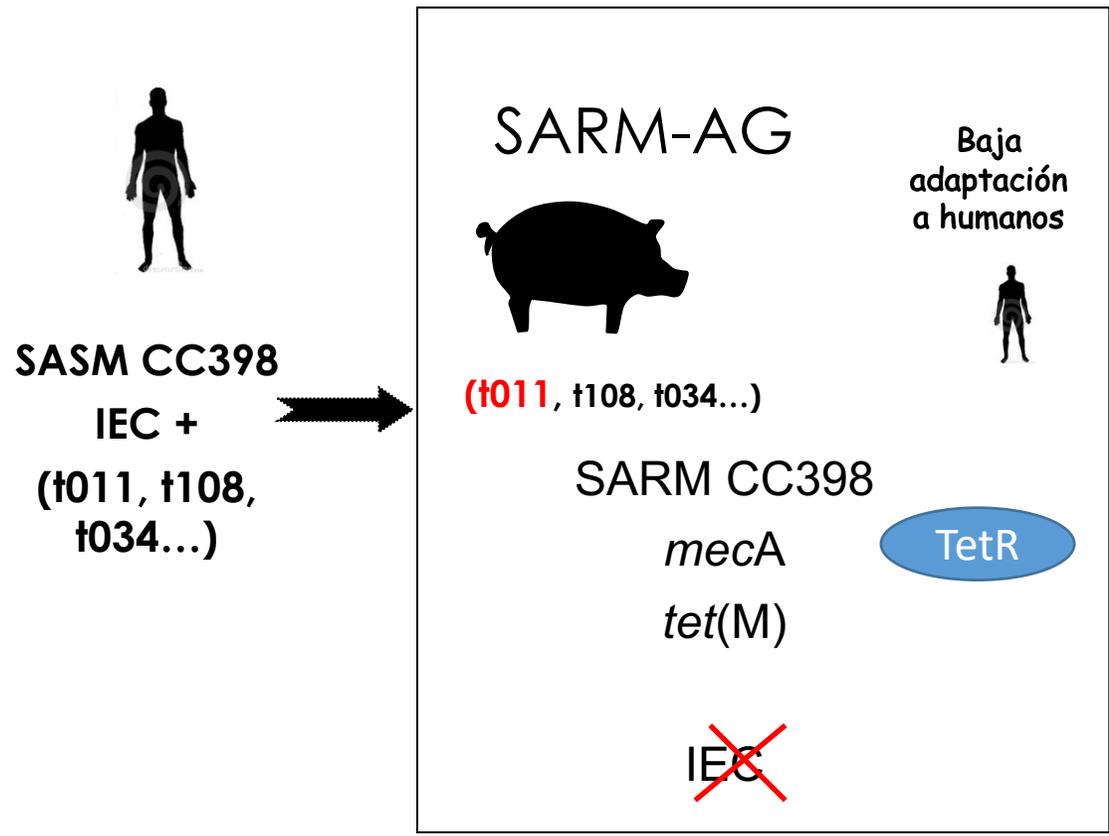
# SARM CC398 en animales vida libre



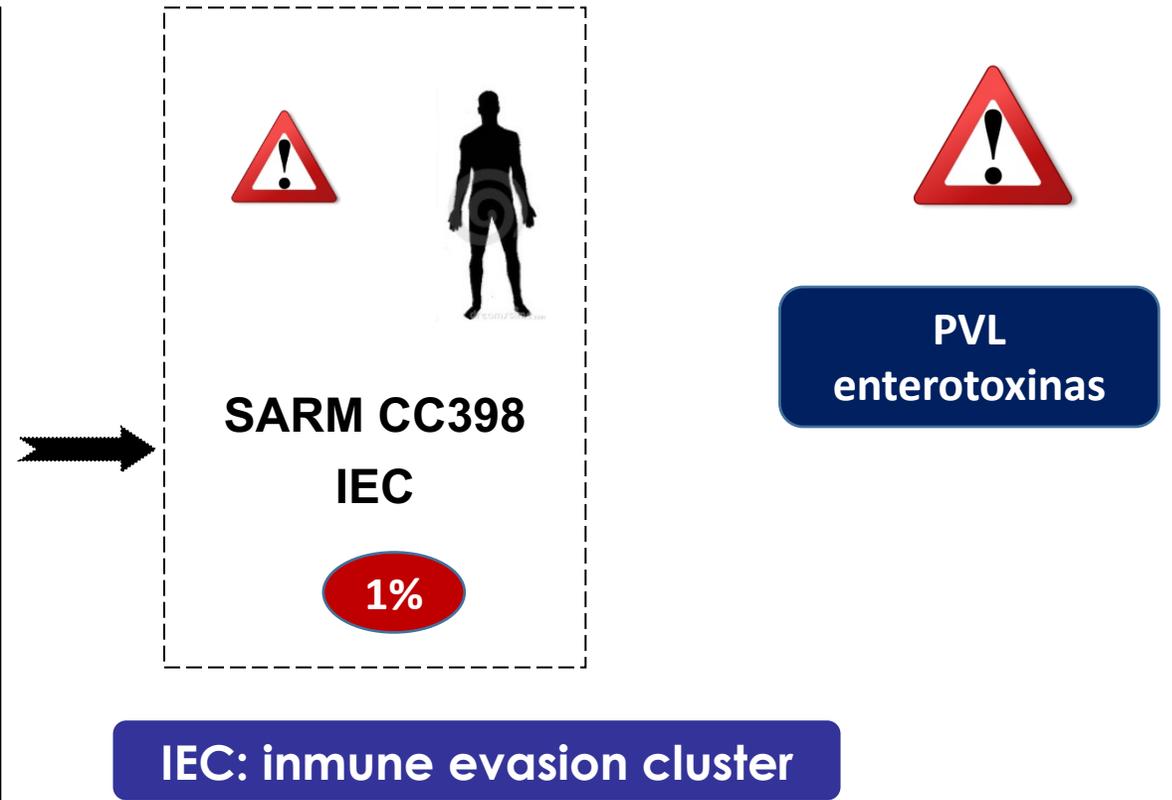
**SARM-ST398**  
**0,5-2%**

**Nuevo mecanismo SARM**  
***mecC***

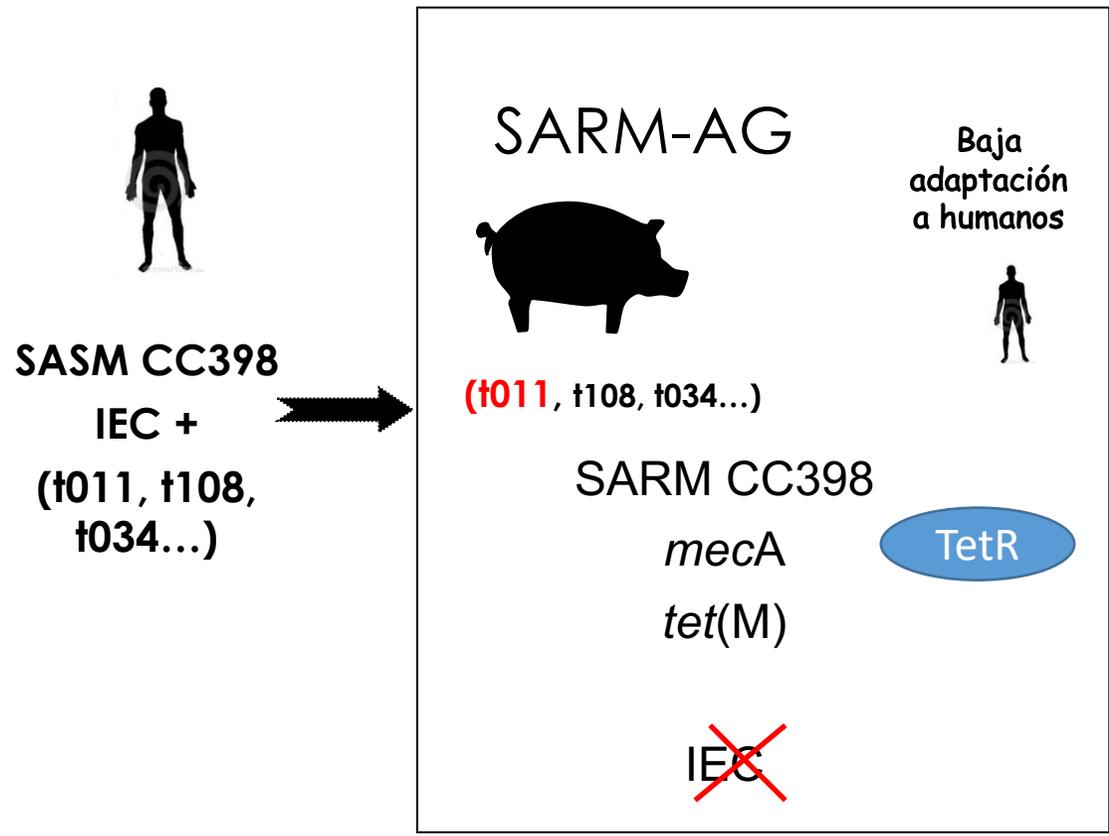
# "Species Jump"



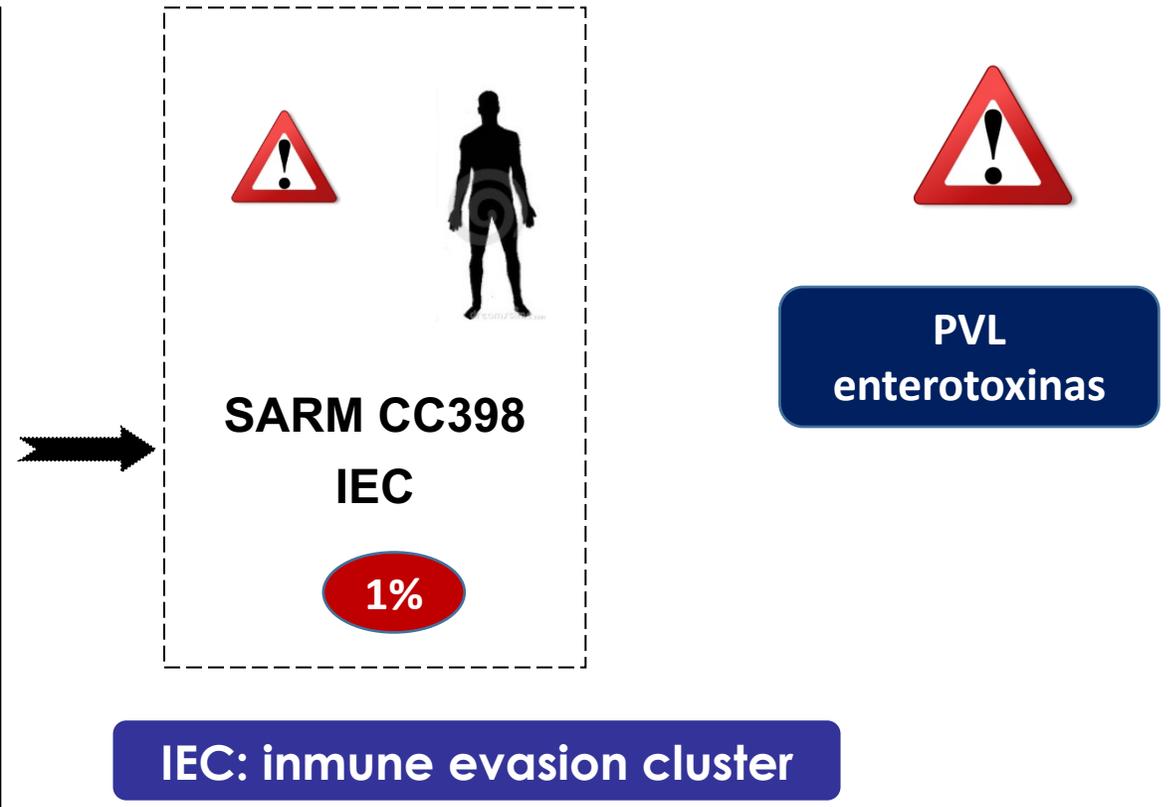
# "Species Jump"



# “Species Jump”



# “Species Jump”



## Unusual presence of the immune evasion gene cluster in livestock-associated MRSA of lineage CC398 causing peridural and psoas abscesses in a poultry farmer.

Pérez-Moreno MO<sup>1</sup>, Centelles-Serrano MJ<sup>2</sup>, Nogales-López J<sup>3</sup>, Domenech-Spanedda MF<sup>4</sup>, Lozano C<sup>5</sup>, Torres C<sup>6</sup>.

**Importante infección en  
humanos**

**Absceso peridural y psoas  
secundario a artritis séptica**

**Granjero de pollos**

**SARM CC398**

**t1451**

***scn* positivo (IEC tipo B)**

# ¿Emergencia de SARM CC398 en el entorno de las granjas porcinas?

- SARM-CC398:
  - Tet<sup>R</sup> (*tetM* +/- *tetK*)
  - MDR
  - Genes of resistance for metals (Zn, Cu..)

**Elevado uso de tetraciclina y otros antimicrobianos en sector porcino**  
**Metales en alimentación porcina (Zn...)**

- Ausencia del sistema IEC
- Carencia del sistema de modificación/restricción tipo-I,



**Incrementa la capacidad de captar e integrar DNA exógeno**

# Genome investigations show host adaptation and transmission of LA-MRSA CC398 from pigs into Danish healthcare institutions

Raphael Niklaus Sieber<sup>1,2\*</sup>, Anders Rhod Larsen<sup>3</sup>, Tinna Ravnholt Urth<sup>2</sup>, Søren Iversen<sup>2</sup>, Camilla Holten Møller<sup>2</sup>, Robert Leo Skov<sup>2</sup>, Jesper Larsen<sup>2,3</sup> & Marc Stegger<sup>1,2,3\*</sup>

SCIENTIFIC REPORTS | (2019) 9:18655 | <https://doi.org/10.1038/s41598-019-55086-x>

SCIENTIFIC  
REPORTS  
nature research



RESEARCH ARTICLE  
Clinical Science and Epidemiology



## Drivers and Dynamics of Methicillin-Resistant Livestock-Associated *Staphylococcus aureus* CC398 in Pigs and Humans in Denmark

Raphael N. Sieber,<sup>a</sup> Robert L. Skov,<sup>a\*</sup> Jens Nielsen,<sup>a</sup> Jana Schulz,<sup>b</sup> Lance B. Price,<sup>c,d</sup> Frank M. Aarestrup,<sup>e</sup> Anders R. Larsen,<sup>a</sup> Marc Stegger,<sup>a,c</sup> Jesper Larsen<sup>a</sup>

November/December 2018 | Volume 9 | Issue 6 | e02142-18

La diseminación de SARM-CC398 en las granjas de cerdos está asociado a los movimientos de animales entre las granjas

La introducción de SARM CC398 en el sistema sanitario se debe a los sucesivos **spillover** desde las **granjas cercanas** vía humano-humano o por cadenas de transmisión ambiental

# Apuntes finales

**SARM-CC398: importante patógeno zoonótico de relevancia en salud pública, y cuyo principal reservorio en animales es el cerdo, aunque esta presente en otras especies.**

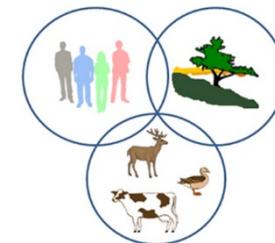
**El contacto ocupacional con animales de granja (especialmente cerdos), es un factor de riesgo de colonización e infección por SARM CC398**

**Estrecha correlación entre frecuencia hospitalaria de SARM-CC398 y la densidad de ganado de regiones adyacentes. Diseminación ambiental?**

**SARM-C398 tiene características fenotípicas y genotípicas, de relevancia para su detección**

***S. aureus* (y SARM) es un microorganismo en continua evolución en la interfaz animal-hombre**

**El enfoque One Health es necesario para abordar el problema de SARM**



One Health



# Agradecimientos

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A. Belles, Hosp. Arnau Villanova,  
 Lerida

Reynaga, A. Vilamala, M.  
 Navarro, Hosp. Vic, Barcelona

Clinical microbiologists  
 of other Spanish hospitals

# Resistencia a antibióticos desde la perspectiva One Health. El caso de *S. aureus* resistente a meticilina (SARM)



**Carmen Torres**

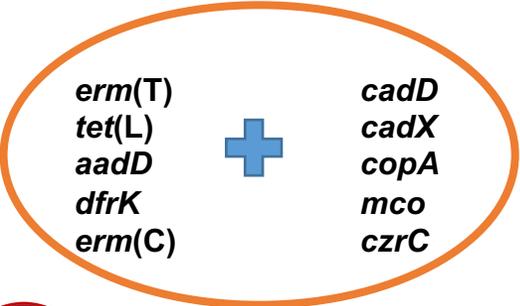
**Universidad de La Rioja**

**León, 20 Octubre 2022**

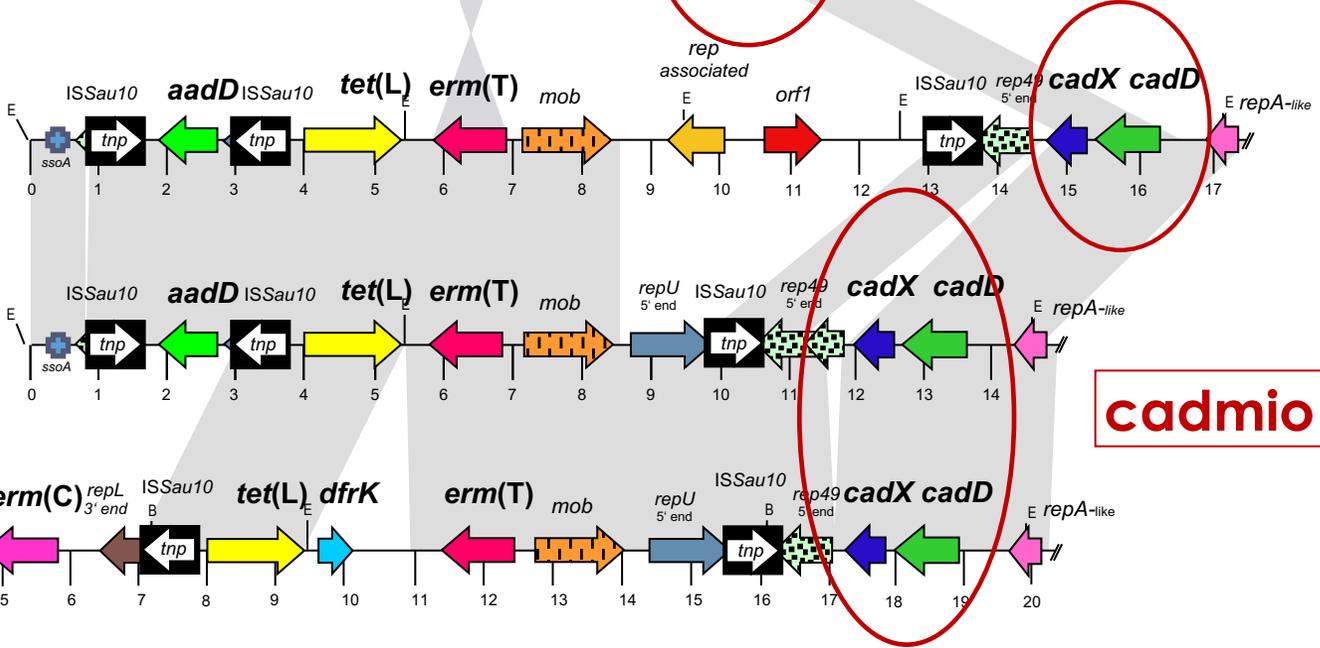
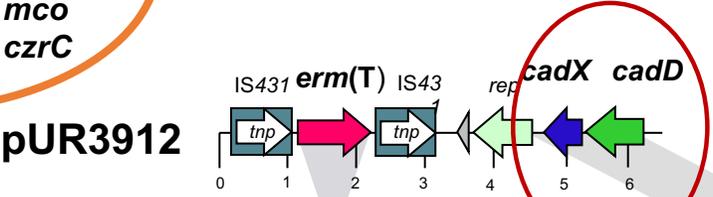
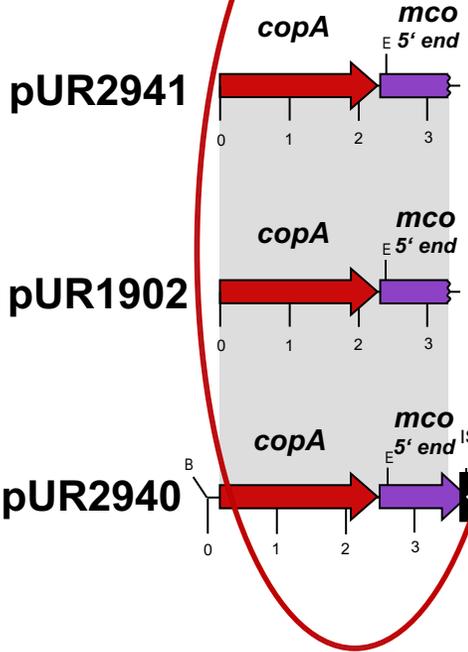
## Características de SARM CC398

- Genes R-Abs nuevos o inusuales
  - *vga* (C)
  - *Inu* (A)
  - *Inu* (B)
  - *isa* (E)
  - *spw*
  - *dfrK*
- Plásmidos con genes R-Abs y a metales pesados
  - *ermT*
  - Cu, Cd, Zn, Hg

# Genes de Resistencia a antibióticos y a metales pesados



**cobre**



**cadmio**



Coagulase-negative staphylococci carrying *cfr* and PVL genes, and MRSA/MSSA-CC398 in the swine farm environment

Laura Ruiz-Ripa <sup>a</sup>, Andrea T. Feßler <sup>b</sup>, Dennis Hanke <sup>b</sup>, Susana Sanz <sup>a</sup>, Carmen Olarte <sup>a</sup>, Oluwafemi Mistourath Mama <sup>a</sup>, Inga Eichhorn <sup>b</sup>, Stefan Schwarz <sup>b</sup>, Carmen Torres <sup>a</sup> ✉



- E. equorum*
- E. arlettae*
- Cfr
- Linezolid-R

## Detection of a *cfr*-positive MRSA CC398 strain in a pig farmer in Spain

[Article in English, Spanish]

Laura Ruiz-Ripa <sup>1</sup>, Alba Bellés <sup>2</sup>, Mercè García <sup>2</sup>, Carmen Torres <sup>3</sup>



Resistencia a linezolid  
Mecanismo *cfr*  
Transferible por conjugación

**Table 1**  
Molecular typing, and antimicrobial resistance phenotype and genotype of the linezolid-resistant MRSA X1761 isolate.

Isolate	Molecular typing				Antimicrobial resistance	
	<i>spa</i> -type	MLST/CC	<i>agr</i>	SCC <i>mec</i>	Phenotype <sup>a</sup>	Genotype
X1761	t011	ST398/CC398	I	V	FOX-OXA-PEN-CLI-AMK-TOB-TET-MIN-CIP <sup>b</sup> -LEV-CHL-FFN-LZD	<i>mecA</i> , <i>blaZ</i> , <i>ant(4')</i> -Ia, <i>tet(K)</i> , <i>tet(M)</i> , <i>cfr</i> , <i>fexA</i>

Journal of Applied Microbiology



2 Original Article

Linezolid-resistant MRSA-CC398 carrying the *cfr* gene, and MRSA-CC9 isolates from pigs with signs of infection in Spain

L. Ruiz-Ripa, A. Bellés-Bellés, R. Fernández-Fernández, M. García, A. Vilaró, M. Zarazaga, C. Torres ✉

First published: 01 January 2021 | <https://doi.org/10.1111/jam.14988> | Citations: 2

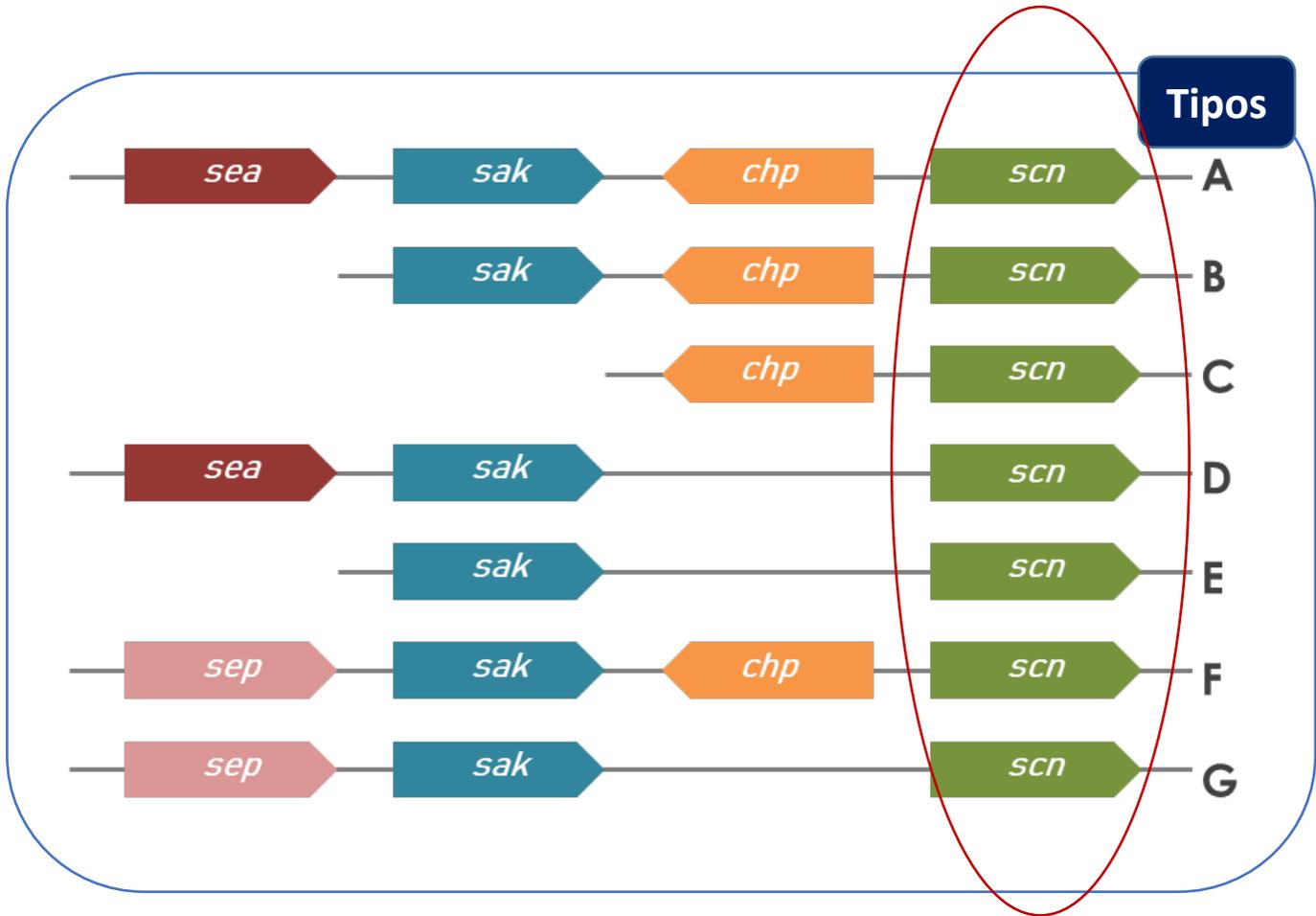
*cfr*  
SARM-CC398  
Cerdo enfermo

X2063	FI	9	Skin lesion	t034	CC398	I	V	PEN-OXA-FOX-ERY-CLI-TET-CHL-LZD	<i>mecA</i> , <i>blaZ</i> , <i>erm(C)</i> , <i>tet(K)</i> , <i>tet(M)</i> , <i>fexA</i> , <i>cfr</i>
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# IEC

## Evasión del Sistema Inmune humano

## SISTEMA DE Adaptación a HUMANOS



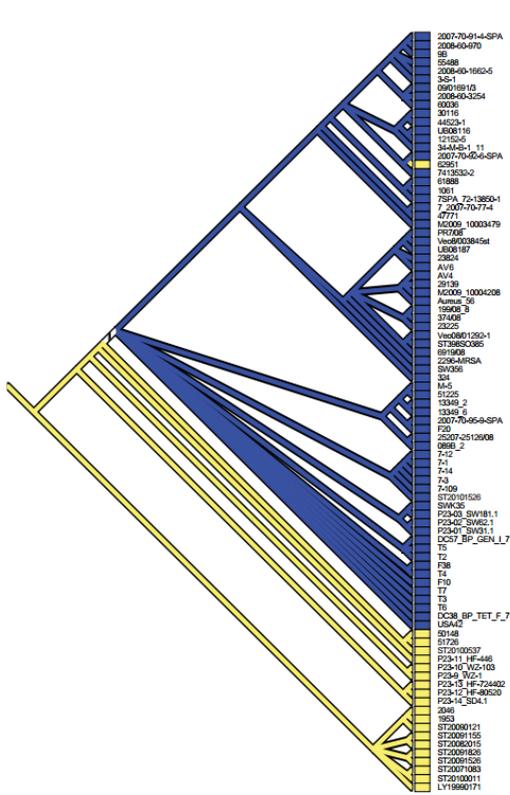
# ¿SASM humano en el origen de SARM-AG ST398??



**Staphylococcus aureus CC398: Host Adaptation and Emergence of Methicillin Resistance in Livestock**

Lance B. Price. Marc Stegger. Henrik Hasman. et al. 2012

Whole Genome Sequence Typing



**Cerdos**  
SARM  
Tet R

**“Salto de especie”**

**Adaptación con pérdida de factores de virulencia y adquisición de nuevos caracteres**

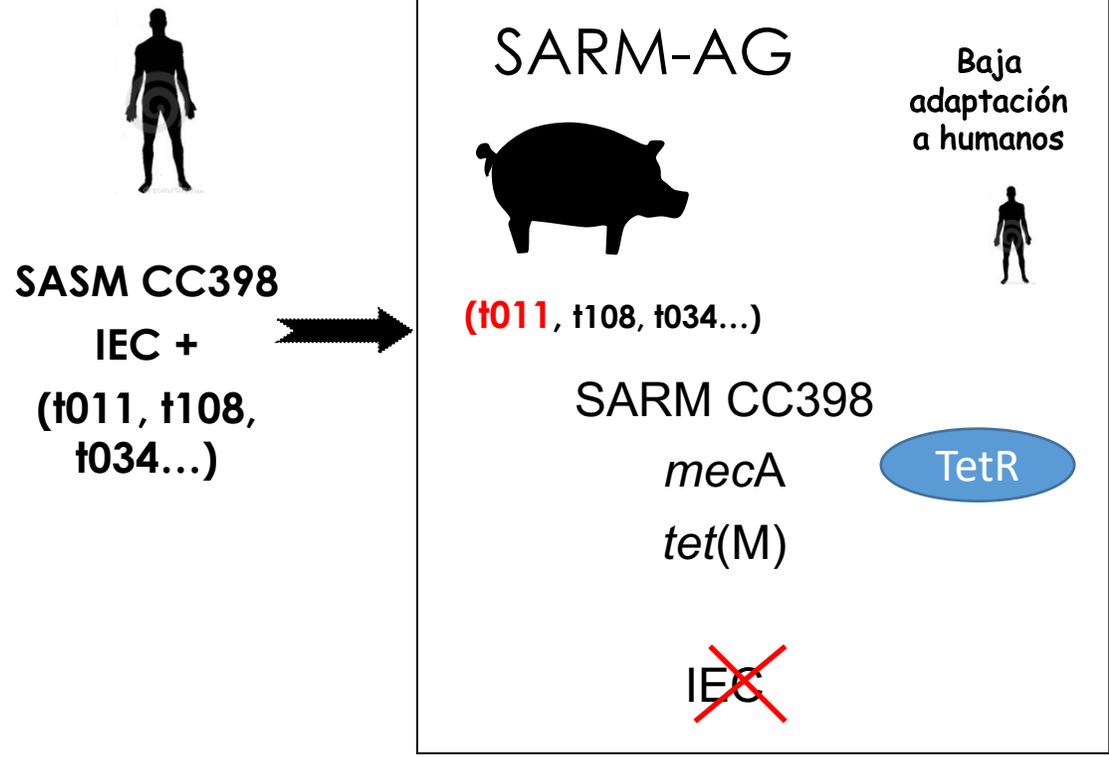


**Humano**  
SASM  
Tet-S  
IEC

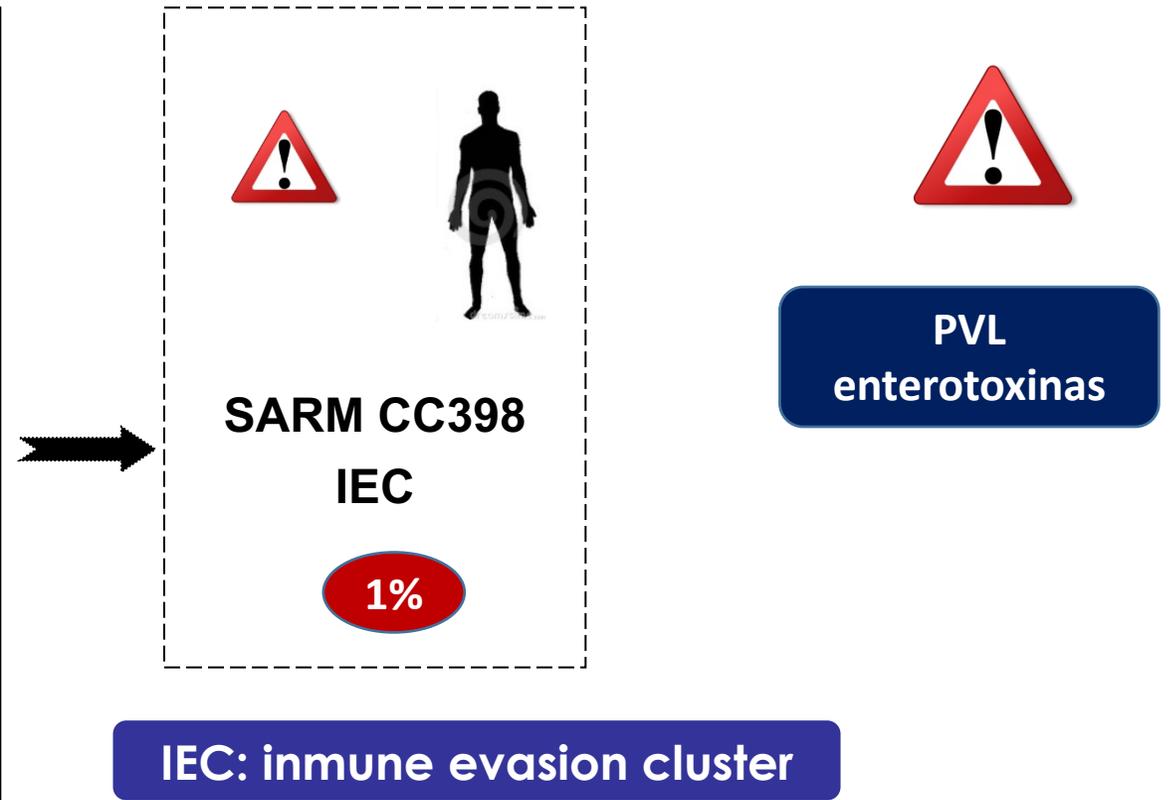
**Genes de evasión sistema inmune**



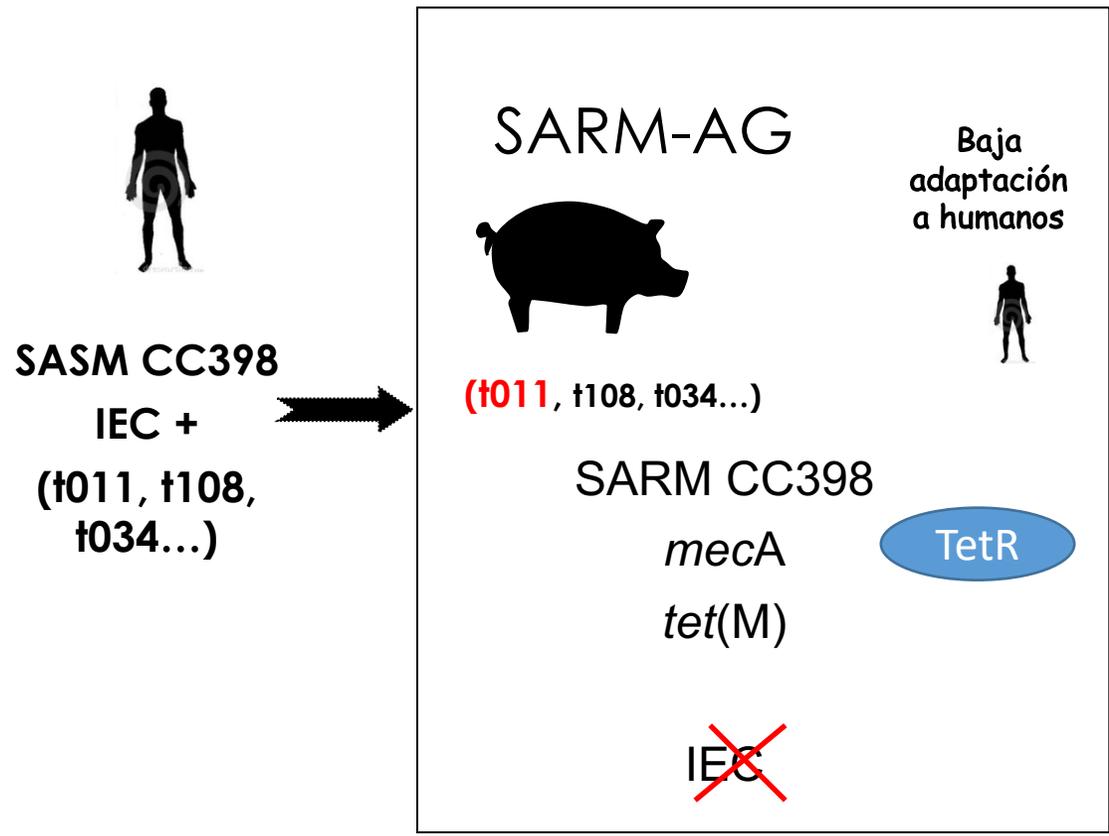
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