What happened after the introduction of USA300 in correctional facilities? A long term follow-up of methicillin-resistant *Staphylococcus aureus* (MRSA) molecular epidemiology in San Francisco jails

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ABSTRACT

We performed a longitudinal analysis of 502 unique methicillin-resistant *S. aureus* (MRSA) clinical isolates originating from San Francisco jail inmates between 2000 and 2007. USA300, first encountered in 2001, accounted for 82.1% (412/502) of MRSA infections. Non-USA300 MRSA were rarely found after 2005 (1 isolate in 2006, 3 in 2007).
Since 2001, a dramatic increase in the number of methicillin-resistant
*Staphylococcus aureus* (MRSA) infections has been observed in the United States,
mostly related to the emergence of USA300 clone in the community (7, 8), and
subsequently in hospitals (21). Correctional facilities inmates were among the first
communities where outbreaks of USA300 MRSA were reported, in Mississippi (3),
Georgia (2), Texas (6), California (20), New York (16), and Canada (5, 17). Thus far, no
long term data are available to describe the evolution of MRSA epidemiology once
USA300 has been introduced in these institutions. USA300 was first encountered in San
Francisco in 2001 (7). We performed a longitudinal analysis of all clinical MRSA isolates
originating from San Francisco jails inmates during the years 2000-2007.

The San Francisco County jail system houses an average daily population of
2,200 inmates in 5 jails (4). A retrospective review was conducted of the electronic
records for all cultures positive for *S. aureus* that were performed in the San Francisco
General Hospital Clinical Microbiology Laboratory, which receives specimens from the
Jail Health Services. Aside from the specimen source, collection date, sex, and age, no
clinical information was accessible. Data collection was approved by the Committee on
Human Research, Office of Research Administration, at the University of California, San
Francisco. Isolates were tested for oxacillin resistance by the salt agar method, and the
presence of the *mecA* gene was confirmed by PCR. Susceptibility to other antimicrobials
agents was tested using microbroth dilution with the MicroScan WalkAway 96 instrument
(Dade Behring), and the results were interpreted in accordance with NCCLS guidelines
(M7-A5). Samples obtained for colonization screening were excluded. Only one isolate
per patient per year was studied. MRSA isolates were genotyped by pulsed-field gel
electrophoresis (PFGE) following \textit{SmaI}-macrorestriction digest of chromosomal DNA (23), \textit{spa} typing (22), and multilocus sequence typing (MLST) (10). USA300 was further defined by the presence of Panton-Valentine leukocidin genes (\textit{lukF-PV} and \textit{lukS-PV}) and the arginine catabolic mobile element (ACME) using PCR assays. SCC\textit{mec} type was identified using a PCR-based protocol (19). Chi-square tests were used for bivariate analysis, and chi-square tests for trend were used to evaluate secular trends. All statistical calculations were carried out using Stata version 9.1 (College Station, TX).

Between 2000 and 2007, 656 cultures positive for \textit{S. aureus} were recorded. Of these, 510 (77.7\%) were MRSA. Eight MRSA isolates were excluded, because they were obtained from colonization screening (\(n=7\)), or were not available for typing (\(n=1\)). Thus, 502 MRSA isolates were analyzed, originating from 494 patients, with a median age of 39 years (IQR 32-47), and a male-to-female ratio of 3.9. There was a significant increase in the incidence of MRSA infections over time ($P=0.01$), from 25 in 2000 to 60 in 2007, while the incidence of methicillin-susceptible \textit{S. aureus} (MSSA) infections remained stable, at ~20 isolates per year. Of the 502 MRSA isolates analyzed, 412 (82.1\%) were USA300 (ST8, SCC\textit{mec} type IVa), 34 (6.8\%) were USA1100 (ST30, SCC\textit{mec} type IVa), 27 (5.4\%) were USA500 (ST8, SCC\textit{mec} type IVa), 16 (3.2\%) were USA1000 (ST59, SCC\textit{mec} type IVa), and 3 were USA100 (ST5, SCC\textit{mec} type II). USA300 appeared in 2001, accounting for 8 of 22 MRSA isolates (36.4\%) that year. Its incidence peaked at 128/140 isolates (91.4\%) in 2004, and stabilized at 45-60 per year from 2005 to 2007, suggesting that USA300 has became endemic in San Francisco jails (Fig. 1). Non USA300 MRSA isolates were rarely found after 2005 (1 of 47 isolates in 2006, 3 of 60 in 2007). MRSA was mostly isolated from skin or skin structure infections (SSSI).
throughout the study period (mean, 92.9% of all specimens). No significant changes in antimicrobial resistance was observed over time for MRSA, with a mean resistance rate at 46.8% for ciprofloxacin, 15.7% for tetracycline, 9.3% for clindamycin, 0.7% for trimethoprim-sulfamethoxazole, and 0.0% for vancomycin and linezolid.

Although previous reports have described community-associated MRSA (CA-MRSA) outbreaks in jails (2, 3, 17), performed colonization surveillance cultures (16, 25), or studied risk factors for MRSA in these settings (5, 6, 24, 25), they focused on limited period of time. This study shows that, 5 years after its emergence in San Francisco jails, USA300 has replaced virtually all previously encountered CA-MRSA clones. As previously reported (15, 18), USA300 was primarily associated with SSSI in this study, and usually susceptible to trimethoprim-sulfamethoxazole, clindamycin and tetracycline (7), with no significant increase in antimicrobial resistance over time as opposed to recent reports from other settings (9, 11). Large jails have been identified as likely foci for the amplification and subsequent spread of MRSA in the surrounding communities (13, 14), and it was predicted that public health interventions directed at these ‘superspreader institutions’ could have a disproportionate impact on controlling CA-MRSA epidemic (12). Our study adds another incentive for improving infection control in these institutions, by showing the persistently high incidence of MRSA infections once USA300 is introduced, in the absence of dedicated intervention.

Guidelines aiming at reducing CA-MRSA transmission in communities are available (1), and significant reductions in MRSA transmission have been achieved in correctional facilities, through a comprehensive intervention program, in Georgia (24).
This study was limited by its reliance on retrospective data collection and the absence of active surveillance cultures. However, as the incidence of positive cultures for MSSA remained stable, it is unlikely that profound changes in sampling policies occurred during the study period. Only documented MRSA infections could be analyzed, although most patients presenting with SSSI in such facilities are treated without microbiological sampling (16). Thus, these figures likely represent an important underestimation of the true incidence of MRSA infections. Despite these limitations, this study shows that USA300, 5 years after its introduction in San Francisco jails, has virtually replaced all previous MRSA clones and is associated with a 2 to 3 times higher incidence of MRSA infections as compared to the pre-USA300 era.
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Figure legend

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