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Isolation and Characterization of methicillin-resistant *Staphylococcus aureus* (MRSA) from Fire Stations in Two Northwest Fire Districts

Marilyn C. Roberts, Olusegun O. Soge, David No, Nicola K. Beck and John S. Meschke

University of Washington, Department of Environmental and Occupational Health Sciences, 357234, School of Public Health, Seattle WA 98195-7234

Abstract

Background. MRSA strains were isolated and characterized from environmental surfaces of two Northwest fire stations from two independent districts. After the first sampling, education was provided, additional signage added and changes in disinfection protocols put in place prior to the second sampling. Nasal carriage of MRSA was determined at the second sampling.

Method. Environmental samples were collected using SANICULT^{TM} swab and RODAC^{TM} plates. Biochemical tests and 16S RNA sequencing confirmed MRSA isolates. Antimicrobial susceptibility testing was performed and the *mec*A gene, MLST typing, and SCC*mec* typing were determined by PCR, sequencing and PFGE analysis.

Results. MRSA was isolated from 44 (4.2%), of 1,064 samples examined and included USA300 isolates. The same strains of MRSA were found in both the garage [medic and fire trucks and protective clothing] and the living quarters. Nasal carriage of MRSA, from one fire district was 22.5%.

Conclusions. Community and hospital-like MRSA were isolated from the environmental samples and the majority of the nasal MRSA/*S. aureus* isolates were genetically related to the environmental MRSA strains suggesting transmission between personnel and the environmental surfaces may be occurring and more research is needed to verify this hypothesis.

N=189

Introduction

Methicillin-resistant *Staphylococcus aureus* [MRSA] was first identified in the 1960's. Over the last 10 years MRSA has become a major nosocomial pathogen for hospitalized and nursing home patients. Known risk factors for MRSA infections includes previous antibiotic therapy, extensive hospital stays, surgery, residence in a long-term care facility, dialysis, the presence of invasive medical devices and colonization.[1,2] However, community-acquired MRSA [CA-MRSA] infections are on the rise and outbreaks of skin and soft tissue infections have occurred among high school, college and professional sports teams, jail inmates, children attending day care centers, and military personnel. These people were previously healthy, with no health care exposure, or known classical risk factors.[3,4] Some risk factors associated with CA-MRSA outbreaks have been identified, including: shared personal care products, frequent skin to skin contact, skin abrasions and crowded living conditions.[3]

S. aureus and MRSA can be transmitted from fomite-to-person and from person-to-person. MRSA has been isolated from whirlpools, razors, towels, gym benches, bar soap, sauna benches and mops.[2,5,6] More recently, 35 homes were sampled and nine found to have MRSA contaminated surfaces including the kitchen and bathroom sinks, kitchen and bathroom faucet handles, counter wiping cloths, kitchen counters, kitchen garbage cans, kitchen towels and bathroom door handles.[7] The highest counts were associated with wet sites.

A recent study sampled commonly touched sites at nine fire-related occupational and training facilities in Tucson and from 160 sites 6.9% were MRSA contaminated with 10^2-10^3 cfu/site.[12] The couches with soft porous material had the highest percentages of MRSA contamination while no MRSA was found in the medic or fire trucks surfaces. In contrast, 49% of ambulances, in southern Maine, were contaminated with MRSA and similar levels were found in a second study of ambulances.[13,14] However in none of these studies were the MRSA isolates molecularly characterized nor were the personnel cultured for MRSA.

Average nasal carriage of MRSA among healthcare personnel is acknowledged to be 5%-12% with < 2% among the general US population while MRSA carriage levels have been found in people previously hospitalized [2.5%], college students [7.5%], and injection drug users [6-35%].[4,8,9,10] However, MRSA carriage levels in health care professionals have ranged up to 50% depending on the type of patients the health care professional worked with, the carriage levels of the patients, when the study was done, and geographic location.[3] In a 1999 study, nasal swab samples were taken from 109 Kansas paramedics to determine their carriage level and a second sample taken 1 year later to determine persistence. In the original sample 5.5% of the paramedics were colonized with MRSA in the first sample. Five of these paramedics were colonized with MRSA in the second sample and based on PFGE analysis three paramedics were thought to carry the same strain in both samples.[11]

In the current study, 1,064 environmental surfaces samples were collected, 44 surface samples were positive for MRSA from the two Northwest fire stations, in two different districts. One isolate from each sample was characterized. Nasal samples were collected from personnel in one of the districts, with nine MRSA positive personnel. Some of the nasal isolates were genetically related to the fire station surface samples. After the first sampling, education was provided to the fire personnel and other changes made prior to the second sampling.

Materials and Methods

Surfaces Sampled. Nine different areas were sampled at each fire station and include 1) medic trucks; 2) fire trucks and fire engines; 3) outer fire gear; 4) garages; 5) kitchens; 6) bathrooms; 7) bedrooms; 8) gyms; and 9) other areas. Between the 1st and 2nd sampling station 2 acquired a new medic truck, while in station 1 the medic trucks are rotated to various stations within the district and as consequence a different medic truck was sampled at each sampling at both fire stations which may have influenced the number of MRSA positive found at the second sample time period.

Environmental Samples. Environmental samples were collected with SANICULT™ swabs (Starplex Scientific Inc., Etobicoke, Ontario, Canada) and on RODAC plates. RODAC plates, which sample ~2.6 cm^2, were placed on a surface once, while a single swab was used to sample a 10 cm^2 area or a single object such as the top surface of computer keyboard, microwave keypad, bag handle and the same sample area was sampled at each time period. RODAC plates detect 10-40% of seeded bacteria and the swabs detect between 10-100 cfu/ml with environmental MRSA, methicillin susceptible *S. aureus* [MSSA] and/or MSSA *S. aureus* ATCC 25923 under laboratory conditions (manuscript in preparation). Swabs were used to sample irregularly shaped frequently touched surfaces within the fire station living quarters, and fire apparatuses [medic, fire trucks and fire engines]; and outer fire clothes. These surfaces were chosen as those most likely to accumulate bacteria and the sample area size swabbed was the same for both Fire Stations and both time periods sampled. Bacto® mStaphylococcus broth [1.5 X] (Difco Laboratories, Sparks, MD, USA) supplemented with a final concentration of 75 μg/ml polymyxin B and 0.01% potassium tellurite (Sigma Co. St. Louis, MO USA) were added to each transport tube. Tubes were incubated in 5% CO_2 at 36.5 ^oC until turbid (24-96 h). The positive samples were 10-fold diluted and plated onto Bacto® mStaphylococcus Medium 110 supplemented with 10 μg/ml methicillin and 0.01% potassium tellurite and Bacto® Mannitol Salts Agar [MS](Difco). Tubes were held for seven days before being labeled as negative for staphylococci. All colonies that grew and had staphylococcal morphology and produced a yellow colony with a yellow zone on MS

were screened for β-hemolysin and verified as *S. aureus* by the Remel Staphaurex® rapid latex test (Thermo Fisher Scientific Remel Products, Lenexa, KS USA).[15]

RODAC plates with Bacto® Staphylococcus Medium 110 supplemented with 10 μg/ml methicillin and 0.01% potassium tellurite were used to sample smooth frequently touched surfaces. Plates were incubated in 5% CO_2 at 36.5 ºC. Black colonies were verified as *S. aureus* screened as described above. Plates were held seven days.

Given that there is limited data on sampling washing machines we developed the following method to sample the washing machines using sterile baby washcloths. The baby washcloths were purchased, sterilized and placed in the washing machines and washed using the warm wash and rinse cycles with the stations' normal detergent. The wet washcloths were placed into sterile bottles and covered with Bacto® mStaphylococcus Broth supplemented with 75 μg/ml polymyxin B and 0.01% potassium tellurite and incubated in 5% CO_2 at 36.5 ºC. Control sterile washcloths were also covered with media and incubated for seven days. Culture positive samples were 10-fold diluted and plated onto Bacto® mStaphylococcus Medium 110 supplemented with 10 μg/ml methicillin and 0.01% potassium tellurite and Bacto® Mannitol Salts Agar (Difco). Colonies were verified as *S. aureus* as described above. Bottles were held for seven days before being labeled as negative. No control washcloths were positive for either *Staphylococcus* spp. or MRSA.

A second set of environmental samples were taken 7-9 months after the first set of samples. During the time period between sampling educational talks were given to personnel, the number of signs reminding personnel to wash their hands were placed around the station. Hand-sanitizers were installed in all the doorways leading from the garage to living quarters and recommendations to disinfect the medic and fire trucks daily were put in place. One isolate/sample was used for further characterization from both the 1st and 2nd set of samples.

The *S. aureus* that were positive for the *mecA* gene were labeled MRSA. Staphylococci that were not *S. aureus* but grew on the methicillin supplemented mStaphylococcus Medium 110 media were

labeled methicillin-resistant coagulase negative *Staphylococcus* spp. [MRCoNS], while staphylococci that that produced pink colonies on the MS media and did not grow on methicillin supplemented mStaphylococcus Medium 110 media were labeled as coagulase negative *Staphylococcus* spp. [CoNS] as previously described.[15]

Nasal Samples. Anterior nasal cultures were collected from 40 healthy fire personnel from 13 stations, the administration and people that move between stations [floaters] using sterile culture SANICULT™ swab. Immediately after collection, the samples were transported to the laboratory and 1.5 X Bacto® mStaphylococcus broth (Difco) supplemented with a final concentration of 75 μg/ml polymyxin B and 0.01% potassium tellurite (Sigma) were added to each tube and incubated in 5% CO_2 at 36.5 ºC until turbid (24-48 h). The enriched nasal samples were plated directly onto MRSA *Select*® Screening Agar (Bio-Rad Laboratories, Hercules, CA) grown at 36.5 ºC without CO_2 and read at 24 h according to manufacturer's instructions. Enrichment of nasal swabs for identification of carriage of MRSA has been previously described.[16] The dark red colonies were tested with the Remel slide agglutination test. A single MRSA isolate from each person was characterized. The subjects' rights were protected and the project had University of Washington Institutional Review Board approval.

Detection of *mecA*, Panton-Valentine leukocidin (PVL) gene, SCC*mec* typing, and Multilocus sequence typing (MLST). *S. aureus* and presumptive MRSA nasal isolates were tested for the presence of the *mecA* gene by a PCR assay as previously described.[15] The *mecA* positive isolates were tested for the PVL gene and SCC*mec* type for type I-V using PCR assays as previously described.[17,18] Those isolates that were not type I-V were labeled non-typeable [NT]. Positive and negative controls were used as previously described.[15]

The MLST PCR assays were performed using previously published primers and conditions with PCR products sequenced bi-directionally at the University of Washington, Genome Sciences High Throughput Sequencing facility, Seattle WA USA. Alleles were assigned by a comparison of their

sequences to the corresponding loci in the *S. aureus* MLST database (www.mlst.net).[19] A clinical USA300 isolate was used as the positive control and negative controls were used for the PCR assays.

Pulsed-field gel Electrophoresis (PFGE). MRSA isolates with the same MLST types were PFGE typed as previously described.[20] The different PFGE patterns were labeled A through S (Tables 3, 4) and the genetic relatedness of the isolates with the same ST type analyzed by Dice coefficient, UPGMA using the GelCompar II software according to the manufacturer's instructions (Applied Maths, Inc., Austin, TX USA). Two different characterized and verified USA300 strains, provided by the WA State Laboratory, were used as positive controls for determination if the MRSA were USA300 as previously recommended.[20]

Detection of Antibiotic Resistance Genes. PCR assays were used to detect the presence of kanamycin resistance gene, *aadD*, macrolide resistance genes, *erm*(A), *erm*(C), and *msr*(A), and tetracycline resistance genes, *tet*(M) and *tet*(K).[15] The PCR products were verified as described previously.[20] Plasmids with cloned *erm*, *msr*(A), and *tet* genes were used as positive controls.[15] The MRSA clinical strain MS361 was used as the positive control for the *aadD* PCR assay. *Enterococcus faecalis* JH2-2 was used as a negative control.[21]

Pearson's Chi-Square Statistical Analysis. Both 2 X 5 and individual Pearson's chi-square test was performed on the data from Table 1 to determine if there was a difference in the percentage of samples that were positive for MRSA, *S.* aureus, MRCoNS, CoNS, or had no staphylococci between the two time periods.

Results

Identification and characterization of MRSA positive samples. Of the 1,064 samples collected, which included 600 samples in the 1st sampling, and 464 samples in the 2nd sampling, a total of 44 samples (4.2%) were MRSA positive, 24 samples (2.8%) were *S. aureus*, 477 samples (45%) were MRCoNS positive, 388 samples (37%) were CoNS positive and 130 samples (12%) were negative for staphylococci after 7 days of incubation. Of the 44 MRSA positive samples, 18% were from the RODAC plates which had *Staphylococcus* spp. counts ranging from 3-41 cfu/2.6 cm^2, medium of 3.5 cfu/2.6 cm^2, with 1-4 colonies confirmed as MRSA/RODAC plate. A 2 X 5 Pearson Chi square analysis determined that there was a statistically significant difference in the distribution of isolates between sampling periods (χ^2=23.1; df =4; p=0.0001). However, individual Chi square analysis determined that only the MRCoNS (χ^2=20.01; df=1; p=0.0000) and CoNS (χ^2=16.06; df=1;p=0.0001) were significantly different between the two sampling periods, with no statistical difference between the two time periods for the three groups; 1) no staphylococci; 2) MRSA, and 3) *S. aureus* (Table 1).

At the 1st sampling, 26 (4.3%) of the 600 surface samples were MRSA positive, with MRSA positive samples found in all 9 areas sampled (Table 2). The most common area for MRSA contamination was the medic trucks with 13 (50%), the kitchens with 3 (11.5%) other areas [computer keyboard and computer desks] with 2 (7.7%). Five MRSA isolates were USA300, the common cause of CA-MRSA infections in North America. Three other MRSA isolates were SCC*mec* type IV but not related to USA300 by PFGE analysis (Table 2). The USA300 isolates were from samples taken from the medic trucks, kitchens, computer keyboards, and computer desk surfaces. The remaining 22 MRSA isolates were not SCC*mec* type I-V [NT]. All 26 MRSA carried tetracycline resistance genes, with the *tet*(M) in 19 isolates, both *tet*(M) and *tet*(K) in six isolates , and the *tet*(K) gene one isolate. Fifteen MRSA isolates carried $\geq$ 1 macrolide resistance gene(s) [*erm*(A), *erm*(M) and/or *msr*(A)] and one MRSA isolate carried a kanamycin resistant gene (*aadD*) (Table 3).

At the 2nd sampling, 18 (3.9%) of the 464 surface samples were MRSA positive, with MRSA positive samples found in all 9 areas sampled (Table 2). The kitchen and outer gear both had 4 (22%) MRSA positive samples, while the medic truck had 3 (16.6%), other areas 2 (11%) and the other five sampling areas had one MRSA positive sample each. Two (11%) MRSA SCC*mec* type II, which is commonly found in hospitals, and were isolated from the fire truck/engine and garage areas. The remaining 16 (89%) MRSA were not SCC*mec* type I-V [NT] and were found among all the areas sampled (Table 2). Five (28%) MRSA isolates were negative for the other antibiotic resistance genes examined, 8 (44%) carried a tetracycline resistance genes [4 *tet*(M), 3 *tet*(M) and *tet*(K), 1 *tet*(K], 11 (61%) carried $\geq$ 1 macrolide resistance gene(s) and 6 (33%) carried a kanamycin resistant gene (*aadD*) (Table 3).

MLST and PFGE typing. Three isolates SNS2100-2218**,** SNS2100-2313 and SNS2100-2380 had MLST patterns not shared with other isolates and were considered to each represent unique strains. Of these strains SNS2100-2313 and SNS2100-2380 had novel ST types not previously characterized prior to the current study [PFGE types Q and R]. The remaining 41 MRSA isolates were analyzed by PFGE and divided into 19 different strains based on their MLST type and PFGE pattern [A-O] (Table 3). Five PFGE groups including types A, F, J, K, and N, had a single isolate represented in study. The remaining PFGE groups had multiple isolates identified on multiple surface samples and four PFGE groups were genetically related to five of the MRSA and two of *S. aureus* isolated from the fire personnel nasal isolates (Tables 3, 4).

Four isolates, with PFGE pattern B, were USA300 and found on medic truck surfaces at the 1st sampling. These isolates were SCC*mec* IV and MLST type ST8 which is one of the most frequently found MRSA MLST clones associated with CA-MRSA disease in North America.[23] Two isolates, pattern E, were SCC*mec* type II, and were isolated from the medic truck and garage floor near the medic truck. Two isolates with pattern M were found in the medic and fire trucks. The three isolates with pattern O came from bunk gear pants, jacket and helmet from a single fire fighter. The remaining

six PFGE pattern isolates (C, D, G, H, I, and L), were found on both trucks/engine/garage and living quarters surfaces in both fire stations, at both 1st and 2nd sampling. Three PFGE pattern C isolates included two isolates that were SCC*mec* type IV, one found on a computer desk at one station and the other on a computer keyboard located in the kitchen at the other station at the 1st sampling. A third isolate was genetically related but was NT and isolated from a computer desk at the 2nd sampling. All three isolates were ST30 which is a widely dispersed clone of MRSA.[23] Nine isolates, with pattern D include one SCC*mec* type IV isolated from the kitchen and one isolated from the bathroom. Of the two isolates with pattern G one was isolated from the garage water cooler at the 1st sampling and one at 2nd sampling was isolated from a bed. The three pattern H isolates were from the bathroom and kitchen and from two fire personnel nasal cultures (Table 3, 4). The six pattern I isolates were found on the fire engine gas pedal, outer fire gear, medic truck, and bathroom from station 1 and in the washing machine in station 2 all at the 1st sampling and in the kitchen of station 2 at the second sampling. The two pattern L isolates were found in the medic truck and kitchen. None of the environmental isolates carried the PVL gene.

Nasal colonization with MRSA. Nine [22.5%] nasal cultures were MRSA positive from fire personnel (representing four different stations [A-D], and a floater, who moves between fire stations within the one district). All strains were NT and seven (78%) were macrolide resistant. However, unlike the environmental surface samples none of the nasal isolates were tetracycline resistant (Tables 4, 5). Seven of the isolates had MLST types ST5, ST15, or ST30 that were also found among the strains of MRSA isolated from environmental surfaces in both fire stations. Five of these isolates were > 90% related to environmental isolates with PFGE patterns C, H, or I (Table 3, 4). Nasal isolate numbers 309 and 325 were highly related to each other but came from personnel assigned to different fire stations. Nasal isolates 300, 340, 312, 301, and 305 were all related to environmental MRSA strains while nasal isolates 303 and 341 had ST types not found in the environmental samples and were not related to environmental MRSA isolates (Table 4). None of the isolates were PVL positive.

Three isolates of *S. aureus* were recovered from nasal samples of which two were from Station A. One was > 90% related to MRSA the nasal isolate numbers 300 and 340, as well as environmental MRSA SNS2100-2258, SNS2100-2359, and SNS2100-2392 isolated from kitchen and bathroom surfaces. A second *S. aureus*, 327, was > 90% related to the MRSA isolate SNS2100-2218 from the medic truck. The third isolate did not have the same ST type as any of the 2nd MRSA isolates and was not analyzed by PFGE since it was unlikely to be related to any of the surface MRSA isolated. Both of these *S. aureus* carried the *msr*(A) gene, making it the most commonly carried macrolide resistance gene among the MRSA/*S. aureus* nasal isolates. In addition, like the nasal MRSA isolates the nasal *S. aureus* were tetracycline susceptible.

Discussion

This is the first study to molecularly characterize MRSA isolates from fire station environmental surfaces and the first study to sample both fire station surfaces and personnel as well as one of the first studies to characterize non-health care environmental MRSA. In this current study, 6.6 % of the environmental samples were MRSA (4.2%) and/or methicillin-susceptible *S. aureus* (2.4%) positive while the majority (> 80%) of the environmental samples was positive for CoNS/MRCoNS. A similar percentage of MRSA positive fire apparatus [medic trucks, fire engines and trucks] and garage samples (57%) vs living quarter (43%) samples were identified in the current study. This is different from the Tucson study where no fire apparatus samples were MRSA positive. However, other studies have found MRSA in ambulances (Maine and Colorado) and in the United Kingdom (http://news.bbc.co.uk/1/hi/wales/4213670.stm).[13,14]

Fire personnel interact with both hospital and community population as part of their job and thus have the potential for exposure to MRSA from both sources. The MRSA USA300 isolates, which are currently the major cause of CA-MRSA in North America, were identified at both stations from medic trucks and kitchen surfaces. MRSA SCC*mec* type II isolates, commonly found in the hospital, were also identified in the study, demonstrated that both community- and hospital-like MRSA can

contaminate the fire station surfaces. The isolation of the same strain in the fire apparatuses and garage as well as the living quarters suggest that the transmission of MRSA may be occurring between these two areas.

Thirty percent of the nasal cultures were positive for MRSA (9 samples) or *S. aureus* (3 samples) among personnel from 10 stations, floaters and headquarter personnel. The majority (58%) of the nasal MRSA and *S. aureus* were genetically related to environmental surface isolates suggesting transmission between personnel and the environmental surfaces may be occurring. These results are different from previous study done among paramedics in Kansas where 54% of nasal cultures were *S. aureus* but only 10% of the *S. aureus* were MRSA.[11] However this earlier study was done 8 years ago and since then the level of CA-MRSA has increased in the USA community.[3,4,8] Clearly more research is needed to determine if the current findings are representative of fire stations surfaces and personnel throughout the country.

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Table 1. Samples positive for MRSA, *S. aureus*, MRCoNS, and CoNS.

	No Samples	No staphylococci (%)	MRSA(%)	*S. aureus* (%)	MRCoNS[a] (%)	CoNS[b] (%)
First sampling	600	79 (13%)	26 (4.3%)	12 (2.0%)	233 (39%)[c]	250 (42%)[d]
Second sampling	464	51 (11%)	18 (3.9%)	13 (2.8%)	244 (53%)[c]	138 (30%)[d]
Total	1,064	130 (12%)	44 (4.1%)	25 (2.4%)	477 (45%)	388 (36.6%)

[a] MRCoNS = methicillin resistant coagulase-negative *Staphylococcus* species; [b] CoNS = coagulase-negative *Staphylococcus* species

Individual Chi square analysis determined that the MRCoNS (χ^2=20.01; df=1; p=0.0000)[c] and CoNS (χ^2=16.06; df=1;p=0.0001)[d] were significantly different between the two sampling periods.

Table 2. MRSA positive surfaces comparing first and second sampling

Location	No of positive samples		Type of MRSA	
Site	First sampling n = 600	Second sampling n = 464	First sampling	Second sampling
Medic truck	13	3	4 IV ST8 USA300, 9 NT	1 II ST105, 2 NT
Fire truck/engine	2	1	2 NT	1 II ST1
Outer fire gear	1	4	1 NT	4 NT
Garage	1	1	1 NT	1 II ST105
Kitchen	3	4	1 IV ST5 USA300 1 IV ST34, 1 IV ST30	4 NT
Bathrooms	1	1	1 NT	1 NT
Bedrooms	1	1	1 NT	1 NT
Gym	1	1	1 NT	1 NT
Others	3	2	1 IV ST30, 2 NT	2 NT
Total	26 [4.8%]	18 [3.9%]	8 IV, 18 NT	2 II, 16 NT
			5 USA300	0 USA300

Table 3. Genotypic characteristics of MRSA isolates from frequently touched Fire Stations surfaces

Isolate(s) n=44	Station	Sample set	Surface(s)	Scc*mec*[a] type	PFGE	USA300	ST	Genotype
RVS700-814	1	1st	Kitchen	IV	A	yes	5	*tet*(K), *tet*(M), *erm*(C), *aadD*
RVS700-808, -810, -841, -851	1	1st	Medic truck[b]	IV	B	yes	8	1 *tet*(K), *tet*(M), *erm*(C); 2 *tet*(M), *erm*(C) 1 *tet*(K), *tet*(M), *erm*(C)
RVR800-1151	1	1st	Other[c]	IV	C[d]		30	*tet*(M), *erm*(A), *erm*(C)
RVS2700-2992	1	2nd	Other	NT	C		30	none
SNS 500-445	2	1st	Kitchen	NT	C		30	*tet*(M
SNS 500-407, -413, -455, -550	2	1st	Medic truck	IV	D		34	4 *tet*(M)
SNS 500-408, -443, -427	2	1st	Medic truck, Bathroom[e]	NT	D		34	1 *tet*(M), *erm*(C), *msr*(A); 1 *tet*(M); 1 *tet*(K), *tet*(M), *msr*(A)
SNR600-5326, -5321	2	2nd	Medic truck	NT	D		34	1 *tet*(M), *erm*(C), *msr*(A); 1 *tet*(M), *mef*(A)
RVS2700-2810, -2905	1	2nd	Garage floor, Medic truck	II	E		105	1 *tet*(M), *erm*(A), *msr*(A); 1 *tet*(K), *tet*(M), *erm*(A), *msr*(A)
RVS2700-2832	1	2nd	Fire engine	II	F		1	*tet*(M), *msr*(A)
SNS500-430, -2327	2	1st, 2nd	Garage, Bed	NT	G		5	1 *tet*(M), *msr*(A); 1 *tet*(K), *tet*(M), *msr*(A), *aadD*
SNS2100-2258, -2359, -2392	2	2nd	Bathroom, Kitchen[g]	NT	H[f]		5	1 *tet*(K), *tet*(M), *msr*(A); 1 *tet*(K), *erm*(C), *aadD*; 1 *tet*(M), *erm*(A), *msr*(A), *aadD*
RVR800-951, -1087	1	1st	Fire engine, outer fire gear	NT	I[h]		15	1 *tet*(M), *erm*(C), *msr*(A); 1 *tet*(K), *tet*(M)
RVR800-921, -1125	1	1st	Medic truck, Bathroom	NT	I		15	1 *tet*(M); 1 *tet*(M), *erm*(C)
SNWC1, SNS2100-2297	2	1st, 2nd	Other, Kitchen	NT	I		15	1 *tet*(M); 1 *msr*(A), *aadD*

RVS2700-2828	1	2nd	Medic truck	NT	J	8	none
RVS2700-2914	1	2nd	Outer fire gear	NT	K	8	none
RVS700-820	1	1st	Medic truck	NT	L	45	*tet*(M)
SNS2100-2404	2	2nd	Kitchen	NT	L	45	*msr*(A)
RVS700-859, 973	1	1st	Medic and Fire trucks	NT	M	59	1 *tet*(K), *tet*(M), *erm*(A); 1 *tet*(M)
RVS700-856	1	1st	Other	NT	N	59	*tet*(K), *tet*(M), *erm*(A)
SNS2100-2345-2350, -2346	2	2nd	Outer fire gear[i]	NT	O	72	1 *msr*(A), *aadD*; 1 *aadD;* 1 *none*
SNS2100-2218	2	2nd	Medic truck	NT	P[j]	97	none
SNS2100-2313	2	2nd	Gym floor	NT	Q	1710[k]	*msr*(A)
SNS2100-2380	2	2nd	Other	NT	R	1711[k]	*tet*(M), *aadD*

[a] NT= not type I-V; [b] Medic surfaces positive included: gurney handle and straps, equipment bag, blood pressure cuff, electronic equipment, inside door, floor, passenger seat, arm rest; [c] Other surfaces includes: washing machine, telephone handle, cloth chair; [d] related [≥ 90%] to nasal isolates 301 and 305; [e] Bathroom surfaces included counter, door handle; [f] related [≥ 90%] to nasal isolates 300 and 340; [g] Kitchen surfaces included; dishwasher handle, toaster handle, refrigerator door handle, floor; [h] related [≥ 90%] to nasal isolate 312; [i] Outer fire gear included: inside and outside of jacket, helmet all from one person's gear; [j] related [≥ 90%] to nasal *S. aureus* isolate 327; [k] Novel ST types

Table 4. Genotypic characteristics of MRSA and *S. aureus* isolated from nasal swabs

Isolate(s)	Station(s)	PFGE	ST	Genotype
MRSA n=9				
300, 340	A	H[a]	5	1 *msr*(A); 1 none
312	floater	I[b]	15	*msr*(A)
301, 305	B, D	C[c]	30	*erm*(C)
305	D	C	30	*msr*(A)
309, 325	A, C	S	30	1 *msr*(A); 1 *erm*(A)
303	C	ND[d]	256	*msr*(A)
341	A	ND	291	none
S. aureus n=3				
313	A	H	5	*msr*(A)
324	A	ND	34	none
327	E	P[e]	97	*msr*(A)

[a] related [≥ 90%] to surface isolates SNS2100-2359, SNS2100-2392, SNS2100-2258; [b] related [≥ 90%] to surface isolates RVR800-921, RVR800-951, RVR800-1087, RVR800-1125, SNWC1, SNS2100-2297; [c] 301 and 305 related [≥ 90%] to surface isolates RVR800-1151, SNS 500-445, RVS2700-2992; [d] NT=not done; [e] related [≥ 90%] to surface isolate SNS2100-2218

Fire and EMS Risk to Infectious Diseases

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IAFC On Scene: May 15, 2010

Return to May 15 issue of *On Scene*

In the fire and emergency service, we rank incidents and operations into predefined categories of risk. Those that fall into the high-risk/low-frequency, such as firefighting, technical rescue and hazmat, get the most attention in preparation and training activities. The next area of risk—high-risk, high-frequency items such as EMS—get less of our time and attention. It's time we change how we think about these types of calls, particularly in the area of risk from infectious diseases.

These days, we do so much EMS we've grown comfortable with it, maybe too much so. Many things in a simple EMS call can reach out and touch us; among other more commonly mentioned concerns is the issue of infectious diseases.

Infectious diseases have been part of the fire and EMS environment since its inception. However, even though the old standbys are still around, there are emerging issues that deserve a bit more attention. Not panic, but attention.

Here are just some of what crews may face every day:

- Meningococcal meningitis
- Hepatitis A, B, C
- Measles/ pertussis
- Chicken pox
- HIV/AIDS
- Tuberculosis
- Vancomycin/methicillin resistance (MRSA, VRE)
- SARS
- West Nile
- C. difficile
- Avian Flu

To address this category of risk, we have many tools. Let's use the four Es to elaborate.

Education

Knowing how infectious diseases are transmitted is half the battle in prevention. Education in how to clean our environment is also important; if we don't clean it correctly, we may give ourselves a false sense of security about safety within our environment.

Engineering

Before entering an environment without knowing if there's an infection risk, we can prepare ourselves by asking three questions when the call comes in:

- Does the patient have a cough?
- Does the patient have a fever?
- Does the patient have a known disease process?

If the answer to any of these is yes, crews should don at minimum gloves, a mask and protective eyewear.

We know certain environments to be even higher risk for diseases: any communal living situation, such as nursing homes, care facilities, prisons, jails, etc. Also, specific patient types including IVDA, homeless, patients with indwelling catheters of any type, and those patients recently released from hospital or the above facilities present an increased risk.

So, if we know these carry more risk, it's important we engineer the workplace to fit it. Use the tested tool of time, distance and shielding. Spend the appropriate time, but no more than needed, in these environments. Distance those who aren't required for immediate patient care, and shield crewmembers with proper PPE.

Engineer into the first-care report some method of noting these environments or patients were encountered. This will provide support when personnel test positive for an item that is considered presumptive, but no significant exposure such as blood in face occurred. Some of these diseases are insidious, such as MRSA or TB, and it's often very difficult to track down what patient was the source.

Enforcement

This is the least favorable of the Es, but when it comes right down to it, we should embrace holding each other accountable. That way, those in the chain of command who are responsible for enforcement won't have to do this. Ultimately, it's each individual's responsibility to ensure their own safety through established best practices, but the officer must ensure compliance.

Economics

If exposures and injury costs go down, this saves money—money that can be spent on other, more sought-after issues or items. Pretty simple.

MRSA and VRE

Methicillin-Resistant Staphylococcus aureus (MRSA) and Vancomycin-Resistant Enterococci (VRE) are types of bacterial infection that can and have killed young, healthy firefighters and EMS professionals. While we focus on MRSA here, VRE is a growing issue for prehospital professionals. Prevention is the key, so here are some important steps for protection of personnel:

- Designate clean and dirty areas of the station. An example is drawing a line between the apparatus bay and station entrances. Nothing dirty passes into the station, such as turnouts, EMS equipment, contaminated materials, etc.
- If budget allows, replace the cloth furniture with a cleanable, pleathery material. When ordering apparatus, this also should be a consideration. MRSA harbors in dust and can live for extended periods outside what we may usually consider the perfect environment of warm and moist. Removing carpeting from dorm rooms is also a good idea.
- Make sure your cleaning products kill MRSA and are EPA registered. When you find one, look at the kill times. Ten minutes is not uncommon, but it's a very long time to ask personnel to ensure a surface remains wet. Some have as low as three-minute kill times.
- Once you choose a product, ensure personnel know how to use it correctly.
- Educate personnel to early recognition and prevention. A perfect, economical way to do this is to use the MRSA education tool, available on the Western Fire Chiefs Association website. Once finished, the program will print a certificate of completion to be used if allowed in your jurisdiction as training.
- Make sure your SOGs match what you want personnel to do. These should include what to do in the event of a MRSA exposure or infection.

Yes, infectious diseases have been around for a long time, and maybe you've never even heard of someone having an issue with them. But we must be diligent and protect our personnel because the effects can be devastating.

Ed Nied is the deputy chief of the Safety/Medical Division of the Tucson Fire Department. He is a director at large of the IAFC SHS Section board of directors, where he chairs the Health Section. He is also the lead State of Arizona Advocate for the Everyone Goes Home Program.

Methicillin Resistant *Staphylococcus aureus* MRSA and Fire Departments

Marilyn C. Roberts, PhD
School of Public Health
Department of Environmental and Occupational Health Sciences

MRSA Disease

- *S. aureus* and MRSA does not cause disease unless the skin is broken or bacteria gets inside the body
- Skin infection often looks like a bug bite
- *S. aureus* and MRSA can be inhaled and cause respiratory disease
- Carriage of MRSA for > 1 year increases risk of disease

Seasonal/Swine Flu and MRSA 2009-10

- Many of the deaths in 1918 flu pandemic was due to secondary infections
- **Today secondary infections with MRSA and other respiratory bacterial pathogens still very important cause of morbidity/mortality**

Fire Station Study

- Bacterial cultures in 1 Seattle and 1 Snohomish Fire Station
- Cultured surfaces in/on Fire Apparatus
- Cultured surfaces in living quarters
- Snohomish cultured washing machine
- Sampling done twice

Fire Station Study

- **Detect level normally ≤ 10% of what is on the surface**
- All MRSA from 1st sampling characterized
- Currently characterizing MRSA from 2nd sampling

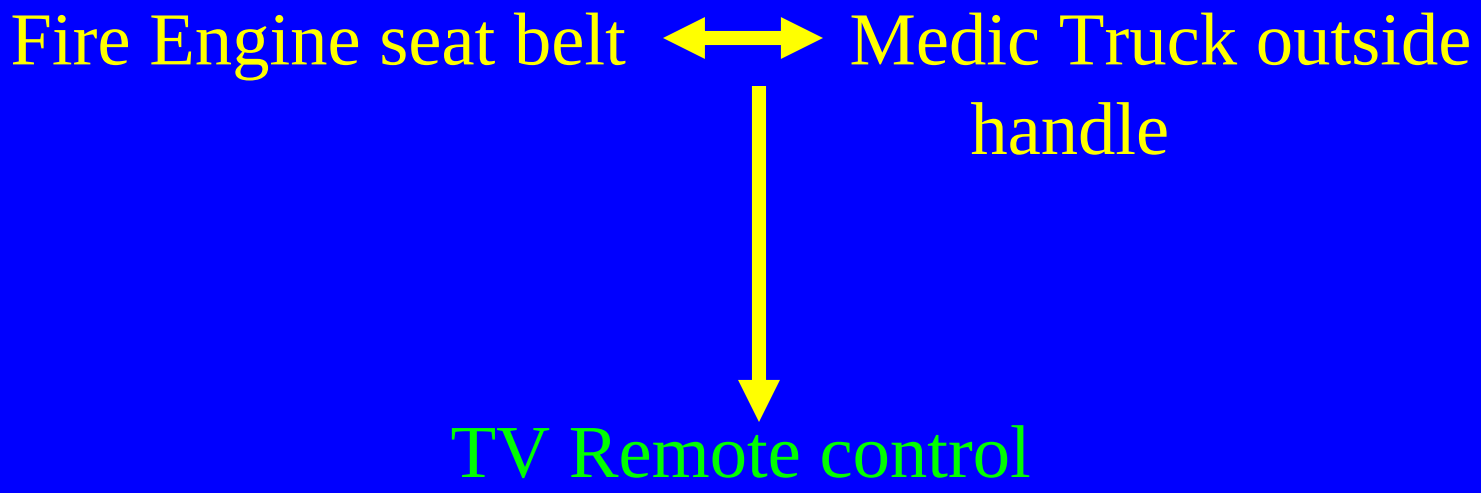
Level of MRSA First Sampling

	Total # samples	MRSA	# MRSA Fire & MT trucks	# MRSA Fire living area
Station A	322	14 [4.3%]	10 [71%]	4 [29%]
Station B	278	12 [4.3%]	6 [50%]	6 [50%]

First Sampling

- MRSA + samples in medic trucks, fire engines and fire trucks
- Found both community and hospital acquired MRSA
- **Same MRSA strains in Fire Apparatuses and Fire Station's living space**
- **MRSA spread from Fire Apparatuses into living space**
- **One strain found in both Fire Stations 35 miles apart**

One MRSA Strain



One MRSA Strain

Seattle

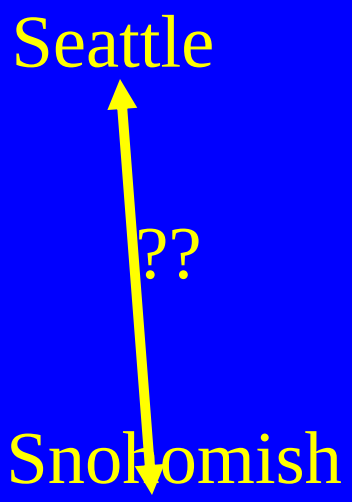
medic Truck electronics, gurney straps, soft bag handle

kitchen sink handle ⟷ men’s bathroom outer door

Snohomish

Washing machine

Why in both Stations?



Share common patient?
Common strain circulating in hospitals/community?
Paramedic trainees?

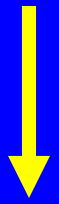
MRSA Positive Surfaces in Living Quarters

Gas/Brake Pedals in this Fire Truck MRSA+

One MRSA Strain

Fire Engine foot pedal  Medic Truck floor

Bunk Jacket



Bathroom Counter

Hypothesis

- Medic truck & Fire apparatuses most likely source of MRSA
- MRSA is spread from hands, shoes, bunk gear, clothing into Fire Station living space
- Once in Fire Station continues to spread
- **Aim to reduce the spread of MRSA by reducing carriage of MRSA from garage into living space**

Changes Made Before Second Sampling

- Education
- Hand sanitizers from garage to living spaces
- Add signs
- Increase disinfection of MT & Fire trucks
- Cover keyboards, move from kitchen

Level of MRSA Second Sampling

	Total # samples	MRSA	# MRSA Fire & MT trucks	# MRSA Fire living area
Station A	195	6 [3.0%]	5 [83%]	1 [17%]
Station B new MT truck	265	12 [4.5%]	4[33%]*	8 [67%]

MRSA/*S. aureus* Carriage

- 40 Fire personnel tested for carriage
- Nine (22.5%) MRSA +, 6 from one station
- Three (7.5%) *S. aureus* +2.5%, 2 stations
- Most nasal MRSA/*S. aureus* were related to Fire Station surface MRSA/*S. aureus* strains

Conclusions

- Community and hospital-like MRSA isolated from fire station surfaces
- Same strain found on fire apparatuses/garage and living quarters suggests that the transmission may be occurring within the fire stations
- Majority of nasal MRSA/*S. aureus* were genetically related to the environmental strains
- Data suggests transmission between personnel and the environmental surfaces may be occurring
- More work needs to be done to verify this

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Fire Personnel Advisory Board

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don't get caught

DIRTY HANDED!

Handwashing is one of the "most important means of preventing the spread of infection," according to the Centers for Disease Control and Prevention (CDC).

bandages ALWAYS make the cut

PRACTICE GOOD WOUND CARE

Keep cuts and scrapes clean and covered with a bandage until healed.

Wash your hands frequently.

YOUR HEALTH MATTERS!

don't take germs home:

WASH YOUR UNIFORM AT WORK

PRACTICE GOOD HYGIENE

Do not share personal items such as towels or razors.

Wash your hands frequently.

Use clean towels each time you shower.

Wash uniforms at the station, not at home.