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Brief report

Tracking sources of *Staphylococcus aureus* hand contamination in food handlers by *spa* typing

Jeffery Ho BSc (hons), Maureen V. Boost PhD, MPH, Margaret M. O'Donoghue PhD*

Squina International Centre for Infection Control, School of Nursing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

Key Words:

Persistent carriage
Nasal colonization
Hand hygiene
Environmental contamination

We aimed to identify the source of *Staphylococcus aureus* contaminating hands of food handlers. Nasal samples and direct fingertip imprints were collected on 2 occasions from food handlers and characterized to determine likely sources of hand contamination. Most hand contamination was attributable to nasal isolates of persistently colonized coworkers who had presumably contaminated the environment. Regular handwashing should be supplemented by effective environmental disinfection.

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Hand contamination of food handlers with *Staphylococcus aureus* is an important risk factor for staphylococcal food poisoning (SFP). Hands may act as vectors transferring the organism to food where enterotoxins may be formed and result in acute gastroenteritis on ingestion. Nasal carriers and contaminated foods are possible sources of *S aureus* contamination.¹ However, studies of *S aureus* carriage in food handlers have mainly focused on nasal colonization,² with limited investigation of the origins of hand contamination. Although hand and environmental contamination in Spanish food handlers was recently investigated, there was no attempt to match sources of contaminating organisms and nasal carriage.³ A Japanese study that investigated transmission using ribotyping demonstrated spread from contamination of cooking equipment and another worker by a colonized food handler.⁴ Because SFP is an important cause of foodborne illness, identification of sources of contamination is essential to determine appropriate hygiene interventions. This study aimed to investigate the sources of *S aureus* contaminating hands of food handlers.

MATERIALS AND METHODS

A total of 548 food handlers from 14 catering establishments located throughout Hong Kong were nasally swabbed by a trained

researcher using a moistened transport swab on 2 occasions, 3–6 months apart, to define nasal carriage status. Swabs were transferred to the laboratory for culture within 2 hours of collection. Persistent carriers were defined as individuals with both specimens positive with the same *spa* type, whereas those positive on 1 occasion were classified as transient carriers. On the second visit, direct fingertip imprint specimens were collected. For any establishment where hand contamination rates exceeded the average by 10%, sampling was repeated 1 month after reinforcement of handwashing training.

Ethical approval was obtained from the University Ethics Committee. Each subject was provided with an information sheet and gave written consent.

Nasal swabs were incubated overnight in 5% salt-supplemented brain-heart infusion broth (Oxoid, Basingstoke, UK) at 37 °C before subculture onto SA Select agar (Bio-Rad UK Ltd, Hemel, Hempstead, UK). Imprints of fingerprints of the dominant hand were obtained on mannitol salt agar (Oxoid). Isolates were confirmed as *S aureus* by latex agglutination (Remel, Lennexa, Kan) and characterized by *spa* typing and comparison with the Ridom database.⁵ To determine the degree of similarity of strains, Simpson's diversity index (*D*) was calculated using standard formulae.

RESULTS

On the second sampling 132 individuals (24%) were nasally colonized and *S aureus* was present on the hands of 16.6% (91 out of 548). Hand contamination was absent at 3 establishments but at 1 site (C) there was a much higher contamination rate (44 out of 62; 71%). Following reinforcement of handwashing, retesting yielded a rate similar to that of the other 10 sites (11.1%) (Table 1).

* Address correspondence to Margaret M. O'Donoghue, PhD, School of Nursing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong.

E-mail address: margaret.o.donoghue@polyu.edu.hk (M.M. O'Donoghue).

Part of this study was presented at the 15th Asia Pacific Congress of Clinical Microbiology and Infection, Kuala Lumpur, Malaysia, November 2014.

This study was funded by a research grant from the School of Nursing, The Hong Kong Polytechnic University, Kowloon, Hong Kong.

Conflicts of interest: None to report.

Table 1
Source of hand contamination and *spa* types of *Staphylococcus aureus* isolated from hands

Site	No. workers (sample 2)	Nasal carriage status			Hand positive (n [%])	Source of hand contamination*			
		P	T	N		Nonnasally colonized workers [†]			Nasally colonized [‡] (endogenous spread)
						Persistent carriers	Transient carriers	Others	
A	26	4	4	18	6 (23.1)	t026 (2)	t127, t2932	t3992	t571 (T)
B	18	4	0	14	1 (5.5)	t085			
C [§]	54	10	6	38	6 (11.1)	t021, t127, t164, t189, t338	t437		
D	28	6	3	19	5 (17.8)	t189 (2)		t032, t2546	t189 (P)
E	125	22	11	92	9 (7.2)	t084 (2), t189 (3), t616	t091, t5864	t213	
F	66	11	3	52	9 (13.6)	t282, t338, t437 (2), t7738	t012, t3092	t668	t437 (P)
G	43	4	2	37	5 (11.6)	t084 (2), t189	t616	t2919	
H	24	3	3	18	1 (4.2)	t189			
I	58	6	3	49	3 (5.2)	t050, t189	t084		
J	45	6	7	32	5 (11.1)	t189	t571	t035, t183	t189 (P)
K	23	5	2	16	3 (13.0)	t437		t082, t701	
L,M,N	30	7	0	23	0				
Overall hand carriage (n = 53)						29 (54.7%)	10 (18.9%)	10 (18.9%)	4 (7.5%)
Diversity index						0.862	1.00	1.00	0.834

N, not a carrier; P, persistent carrier; T, transient carrier.

*Putative source of hand contamination was defined by *spa* typing of hand isolates. Source attributed to presence of a *spa* type of a hand isolate that was identical to that of a nasal isolate from a persistently or transiently colonized coworker in the same workplace.

[†]*Spa* type (number of isolates belonging to a given type, shown only if >1).

[‡]*Spa* type and nasal colonization status of hand-contaminated subject.

[§]Site C: Second sample after handwashing training. Eight subjects had left their employment at this time, reducing the total number to 54.

^{||}Three sites where no hand carriage was observed.

Of 53 subjects with hand contamination, the strain present on 4 sets of hands was identical with their own nasal strain. Three of these 4 workers were persistent carriers. Hand carriage isolates of 29 out of 49 noncolonized food handlers revealed identical *spa* types to the nasal isolates from persistently colonized coworkers. Of the remaining 20 hand-colonized subjects, 10 had isolates matching *spa* types of transient carriers within the same workplace, whereas the remainder yielded *spa* types distinct from the nasal isolates of their coworkers (Table 1). The risk of a noncolonized worker being contaminated by a strain carried by a persistently colonized coworker was considerably higher (odds ratio, 5.66; 95% confidence interval, 2.12-15.45; $P = .002$). Before improvement of handwashing in the poorly compliant establishment, 46.3% of exogenous contamination was from persistent carrier strains, 12.2% was from transient carriers' strains, and the remaining 41.5% was from unrelated strains. The 3 persistent carriers each harboring the same strain on their hands and noses appeared to be superspreaders (Fig 1). The proportions from persistent, transient, and other sources became 83% (5 out of 6), 16.7% (1 out of 6), and 0, respectively, after improvements in handwashing (Table 1).

Spread of a persistent carrier's *spa* type to a coworker's hands was observed in 3 sites. At both sites D and J, there was a single nasal carrier of t189 with contaminated hands and other noncolonized workers had hand contamination with this strain. A similar scenario was observed with t437 at site F (Table 1).

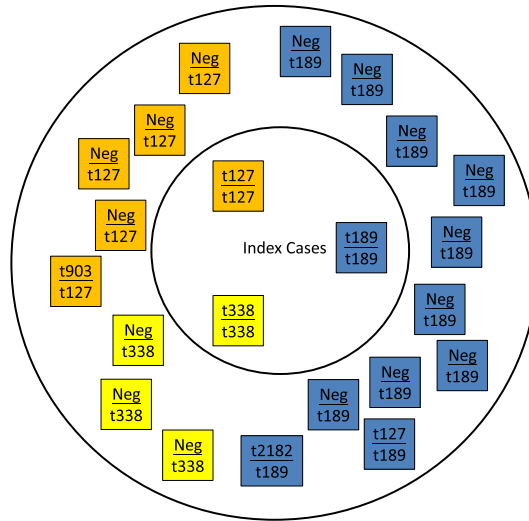
In total, 13 *spa* types present on hands matched those of persistent carriers and 10 matched those of transient carriers. Three *spa* types from persistent carriers predominated: t189 (45.8%), t127 (14.6%), and t338 (12.5%). Diversity index determination revealed that strains of persistent carrier origin ($D = 0.862$) are more closely related than those of other origins ($D = 1.00$).

DISCUSSION

By use of a large population of food handlers, repeated sampling to determine carriage status, and use of *spa* typing, we were able to reveal that persistent nasal carriers are likely to be the most

important source of hand contamination, accounting for more than half of the isolates. Such transmission would most likely occur indirectly, as a result of nasally contaminated hands of colonized workers contaminating the environment, utensils, or food, which are then in contact with other food handlers. The lower diversity of *spa* types from hand isolates matching nasal isolates from persistent carriers rather than those of transient carriers indicated that the majority of contamination may be originating from a few persistent carriers. The most frequently isolated strain—t189—is commonly isolated from human infections in Southeast Asia⁶ and has been isolated from pork products, including local roasted pork.⁷ Types t091, t127, and t701 have been implicated in food poisoning outbreaks in China,⁸ and types t127 and t084 have been implicated from SFP isolates from Germany.⁹

Persistent carriers harbor higher loads of the organism and may contaminate their hands and surrounding environments.¹⁰ Environmental contamination can lead to transmission to hands of noncolonized workers who may become transient carriers and/or transfer the organisms via their hands to food.⁴ Up to 90% of nasal carriers have been shown to simultaneously harbor the bacteria in their noses and on their hands.¹⁰ However, in our study, endogenous hand contamination was surprisingly rare, which might be attributable to regular handwashing, because reinforcement reduced isolation of these strains at site C. Environmental contamination from persistent carriers may also involve aerosols from these workers in addition to the usually considered nose-to-hand-to-environment transmission route. Reinforcement of handwashing also led to elimination of *spa* types from sources other than colonized coworkers. This indicates handwashing before commencement of work removes contamination from outside the workplace. Since the severe acute respiratory syndrome outbreak, hand hygiene has improved as a result of government initiatives, including appointment of hygiene supervisors to monitor handwashing. The overall low level of hand contamination we found was similar to the 9% reported for Finnish airline-catering workers¹¹ and 8.4% reported for Spanish food handlers.³



Workers	Hand positive	Nasal carriage status		Source of Hand contamination				
		P	T	N	Persistent	Transient	Others	Colonized (endogenous)
62	44 (71%)	10	7	45	t127 (5), t189 (11), t338 (3)	t084 (2), t091 (2), t903	t034, t081, t085, t148, t179, t213, t321, t402, t688, t1080, t1081 (2), t1190, t2314, t2459, t2575, t6379	t127, t189, t338

Fig 1. Spread of *Staphylococcus aureus* between food handlers in site C before reinforcement of handwashing. Each square represents one person. The *spa* type on upper and lower rows indicates *spa* type of *S aureus* isolated from nose and hands, respectively.

CONCLUSIONS

The majority of hand contamination appeared to be attributable to cross-contamination from persistently colonized coworkers who presumably contaminated the environment. This emphasizes the need for improvements in environmental disinfection in addition to handwashing to reduce transmission to other workers. Use of gloves and masks for those handling foods is recommended because it is not feasible to define carriage status.

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