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Background Analysis of Community Acquired Pneumonia: Environmental Bio contamination in Residential Spaces

Kembu Nakamoto, MD, PhD, Sadahiro Kawamoto, MD, Yuko Kawamura, MD, Nobuyasu Tahara, MD, Toshiyuki Fujii, MD, PhD and Hiroshi Hashiyada, MD

Division of General Thoracic Surgery and Division of Respiratory Medicine, Institutional Infection Control Team, Shunan Memorial Hospital, Kudamatsu, Yamaguchi, Japan.

***Correspondence:**
Dr K Nakamoto, 1-10-1 Ikunoya-minami, Kudamatsu, 744-0033 Yamaguchi, Japan, Tel: +81833-45-3330, Fax: +81833-45-3331.

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ABSTRACT

Objective: *The cause of the prevalence increase in community-acquired pneumonia is unclear. The environmental bio contamination of residential spaces was investigated.*

Patients and Methods: *A retrospective analysis of 146 pneumonia patients admitted between January 2019 and December 2019 was performed. Age, living status, smoking status, and nursing care status were assessed. Bio contamination in residential spaces and the bactericidal effects of tobacco, incense-stick smoke and electrolyzed saline (ES) were examined using Koch's method.*

Results: *The patients were quite old (mean age: 80.9 ± 12.6 y.o.). Living in a private residence, where smoking tobacco, pesticide and incense-stick use might be allowed, carried a low risk of pneumonia (OR: 0.026, 95% CI: 0.003–0.190). Current smokers had a low risk of pneumonia (OR: 0.348, 95%CI: 0.143–0.844). Patients that did not require nursing care had a low risk of pneumonia (OR: 0.004, 95%CI: 0.001–0.026). Significantly more colony-forming units (CFU) were detected in communal spaces than in private spaces (5.85 ± 1.41 vs 0.30 ± 0.24 CFU/5 min). Significantly more CFU were detected in places where smoking was restricted than in spaces where smoking was allowed (5.90 ± 1.49 vs 1.24 ± 0.79 CFU/5 min). However, the examined residential spaces were generally clean. The number of CFU in vocalized droplets was very high (thousands). Both tobacco and incense-stick smoke had bactericidal effects on droplet-borne bio contamination; i.e., they reduced the number of CFU by >90%, as did ES solution, which also suppressed oropharyngeal bio contamination.*

Conclusions: *Smokeless residential environment might be responsible to the prevalence increase of community-acquired pneumonia. ES might contribute to preventing pneumonia epidemics.*

Keywords

Pneumonia epidemics, Bio contamination.

Introduction

The prevalence of community-acquired pneumonia among elderly Japanese people has been increasing since the late 1970s [1], in spite of an increased prevalence of pneumococcus vaccine inoculation, advances in hygiene and sanitation techniques, and reductions in the use of tobacco and Buddhist or pesticide-containing incense sticks [2,3]. The cause of the increase in the prevalence of pneumonia is unclear. As baby boomers are joining the elderly generation, the prevalence of pneumonia among the elderly is predicted to increase further. The environmental background, especially bacterial contamination, in modern residential spaces was investigated.

Patients and Methods

The institutional review board of our hospital granted ethical approval for this study (IRB approval #02-02, SMH, Nov. 11, 2020). Informed consent was obtained from each patient. In this retrospective study, data were acquired from attending physicians and/or electronic medical records, or through telephone inquiries.

One hundred and forty-six patients that were admitted to our hospital with pneumonia between January 2019 and December 2019 before COVID-19 pandemic aera were enrolled in this study. Each patient had their age, sex, current smoking status, activities of daily living, and whether they lived in a private residence or a nursing home recorded. The patients were compared with 166 individuals who visited our hospital to undergo CT examinations for lung cancer in the same period. Airborne and vocalized droplet bio contamination in residential spaces were also investigated using Koch's method [4].

The airborne bio contamination of public or private indoor spaces during active human use was also examined. Agar culture plates were placed on tables for 5 minutes in the outpatients' lounge; inpatients' dining room; a private home; a public smoking cabin; a cafeteria that allowed smoking; and a Buddhist temple, where incense sticks are burnt all day long, as well as on the dashboards of communal or private vehicles.

The antibacterial effects of biomass, tobacco, and incense-stick smoke against the bacteria within vocalized droplets were compared with those of electrolyzed saline (ES) solution, a novel disinfectant that does not have toxic effects on biological tissue [5]. The vocalized droplets produced by phonation of the sounds "Ba-Bi-Bu-Be-Bo-Pa-Pi-Pu-Pe-Po" on a sterilizedφ37-mm round plastic plate were exposed to homogeneous smoke flow from 6 Japanese incense sticks at a distance of 20 cm or from a cigarette at a distance of 20 cm over a 5-minute period, or one spray of ES, which we employ as a standard disinfection technique for skin, oral, and tracheal hygiene. Stamp smears from the plastic plates were incubated on agar culture plates at 37℃ for 48 hours. The number of colony-forming units (CFU) on each plate was counted. The suppressive effects of gargling ES on oropharyngeal bio contamination were also investigated using droplet agar cultures.

Custom made ES preparation; ES aqueous solution was produced from 0.1% salt tap water mixture using a water electrolysis generator (Oxilyzer Medical C-L, Koken Ltd., Tokyo). Electrolyzed strongly acidic water with a pH of less than 2.8 was generated at the anode compartment and was collected for use.

Statistical analyses

For comparisons of patient characteristics and risk factors between two groups, odds ratios (OR) were calculated for categorical variables, and the Student's t-test was used for continuous variables. Continuous variables are expressed as the mean ± standard deviation. P-values of <0.05 were considered to be significant. Microsoft Excel software (Excel statistics 2020; Ekuseru-Toukei 2020, Social Survey Research Information Co. Ltd and Tokyo) was used for all statistical analyses.

Results

One hundred and forty-six patients with pneumonia, excluding aspiration pneumonia, were admitted to our hospital between January 2019 and December 2019 (Table 1). Ten of the 146 pneumonia patients had viral pneumonia, and the remaining 136 had bacterial pneumonia. Pneumococci, a common pneumonia pathogen, were only detected in 8 of the 136 bacterial pneumonia patients. No seasonal outbreaks were noted. The mean age of the patients was quite high (80.9 ± 15.1 y.o.), and there were 82 males and 64 females. Living in a private residence, where tobacco smoking or incense-stick use might be allowed, was also associated with a low risk of pneumonia (Odds ratio [OR]: 0.026, 95% confidence interval [95%CI]: 0.003–0.190). The current smoker prevalence ratio of the pneumonia patients was 7/136, while that of the controls was 21/145. Current smokers were found to be at low risk of pneumonia (OR: 0.348, 95%CI: 0.143–0.844). Patients that did not normally require nursing care were demonstrated to be at low risk of pneumonia (OR: 0.004, 95%CI: 0.001–0.026).

Airborne bio contamination of residential spaces (Table 2)

Table 1: Patient's characteristics and risk factors for pneumonia.

Risk factors	Pneumonia Pts.	Controls	Odds ratio	95%CI
Viral/bacterial pneumonia	10/136	-		
(Pathogens: pneumococci/others/non-specific 8/83/55)				
Season (warm/cold)	74/72	-		
Age (years)	80.9 ± 15.1 y.o.	64.6 ± 9.9 y.o.	(P<0.001)	
Sex (male/female)	82/64	94/72	0.981	0.627-1.537
House type (private/facility)	118/28	165/1	0.026	0.0030.190
Current smoker (yes/no)	7/139	21/145	0.348	0.143-0.844
Nursing care (no/yes)	54/92	165/1	0.004	0.001-0.026

Table 2: Airborne bio contamination of residential spaces.

	Private spaces (n=4)	Communal spaces (n=20)	P-value
CFU/5 min	0.30 ± 0.24	5.85 ± 1.41	0.0027
	Smoking spaces (n=5)	Non-smoking spaces (n=19)	
CFU/5 min	1.24 ± 0.79	5.90 ± 1.49	0.035

Communal spaces contained more bacteria (5.85 ± 1.41 CFU/5 min) than private spaces or those that allowed smoking (0.30 ± 0.24 CFU/5 min). Spaces in which smoking was restricted contained significantly more bacteria (5.90 ± 1.49 CFU/5 min) than spaces in which smoking was allowed (1.24 ± 0.79 CFU/5 min).

Bacterial contamination of vocalized droplets

The number of bacterial colonies within vocalized droplets was much larger (thousands of colonies) than the number of airborne colonies.

Bactericidal activity of biomass smoke against bacteria within vocalized droplets (Figure 1).

Both tobacco smoke and incense-stick smoke reduced the number of CFU cultured from vocalized droplets to 95% of that seen in the

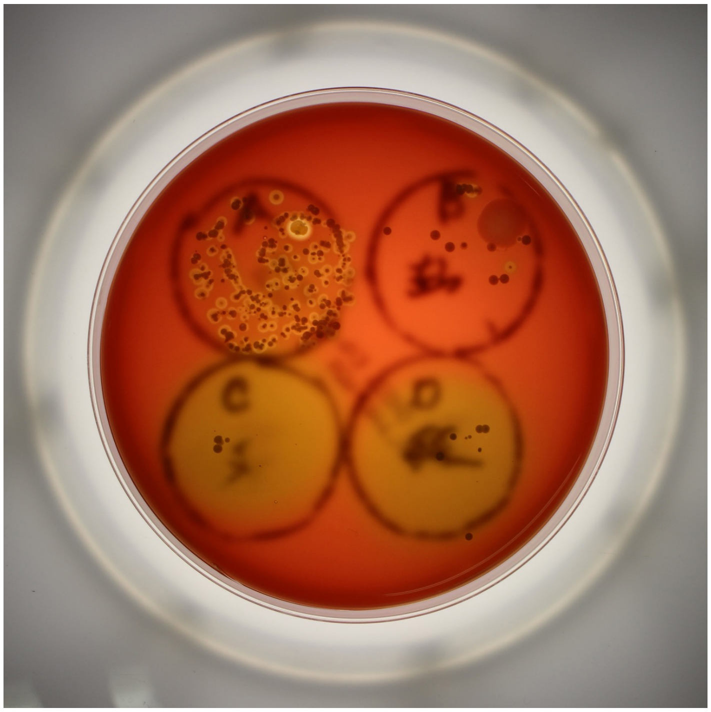

Figure 1: Offensive bactericidal activity of biomass smoke.

Stamp smears of vocalized droplets were cultured and examined. Both types of biomass smoke suppressed colony formation as well as electrolyzed saline (ES) mist; i.e., by 95–99% of the control value. Circle A (top left): control; Circle B (top right): exposed to a single spray of ES mist; Circle C (bottom left): exposed to cigarette smoke for 5 mins, Circle D (bottom right): exposed to smoke from 6 incense sticks for 5 mins. (Sampled from an elderly male volunteer).

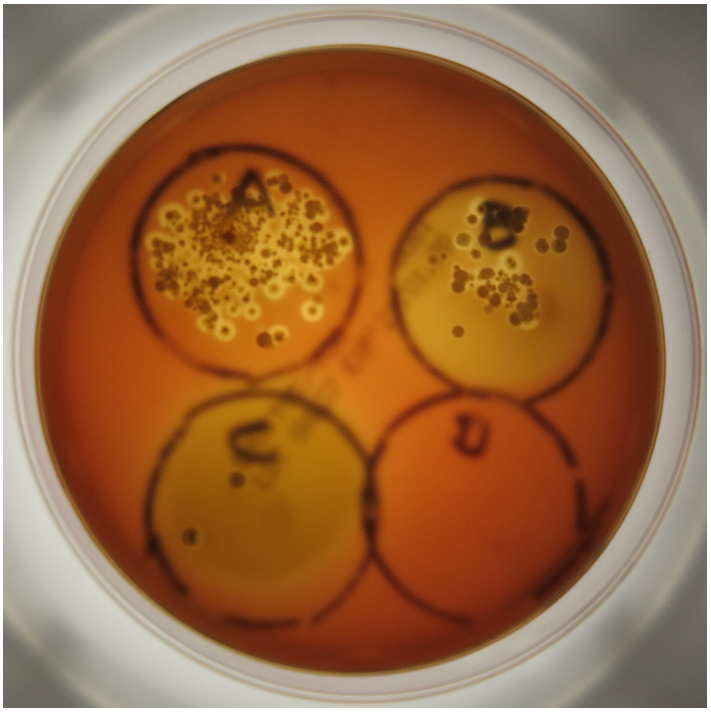

Figure 2: Defensive bactericidal activity of biomass smoke.

Stamp smears of vocalized droplets on a plastic plate that had precoated with smoke particles were cultured and examined. Both precoated tobacco and incense-stick smoke suppressed colony formation by 85–99% of the control value. Circle A (top left): control; Circle B (top right): exposed to vocalized droplets after being pretreated with smoke from a cigarette for 5 mins; Circle C (bottom left): exposed to vocalized droplets after being pretreated with smoke from 6 incense sticks for 5 mins; Circle D: empty (Stamp smear of sterilized plastic plate with electrolyzed saline without droplet exposure). (Sampled from a middle-aged male volunteer).

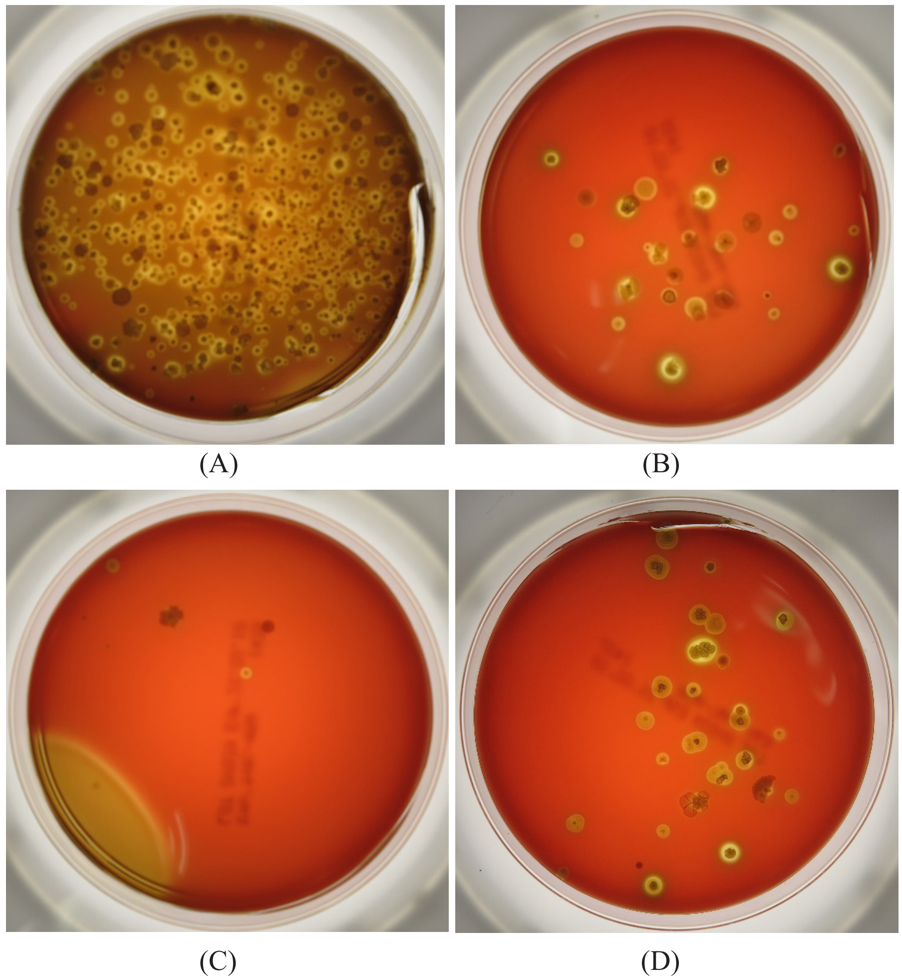

Figure 3: The effects of electrolyzed saline (ES) solution on oral hygiene and the duration of these effects.

Gargling with ES once reduced the number of colony-forming units (CFU) by 90%, and gargling with ES 10 times reduced the number of CFU by over 99.9% of the control value. The number of CFU was reduced by 80% of the control value for several days. (A) Control agar plate containing vocalization droplets; (B) Droplets produced after gargling once with ES solution; (C) Droplets produced after gargling with ES 10 times; (D) Droplets produced after 4 days of ES-based oral hygiene (sampled from a young female volunteer without dental caries).

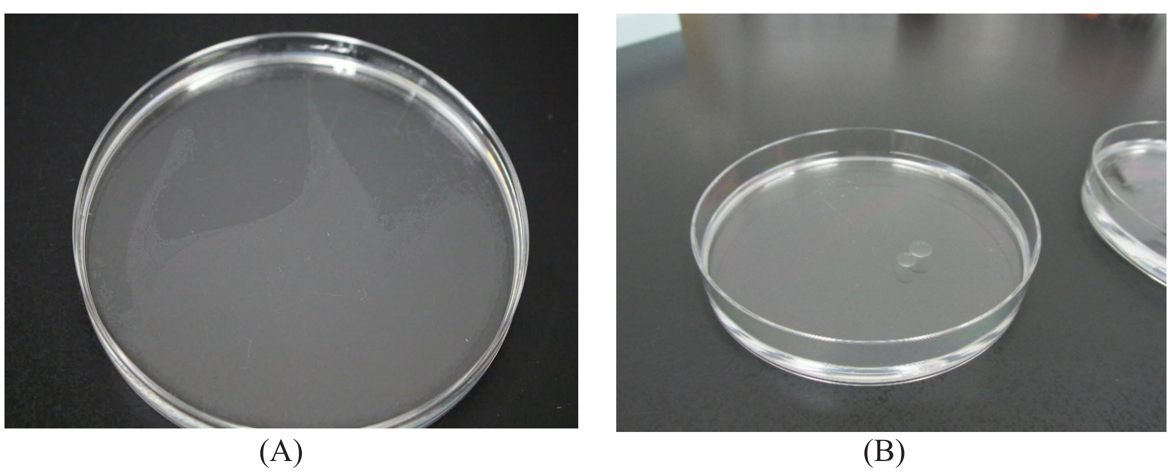

Figure 4: Hydro lipid affinity of electrolyzed saline (ES).

A. Two droplets of salad oil instantly covered the surface of the ES solution at pH 2.8.

B. Two droplets of salad oil maintained their shape on the surface of tap water.

control stamp smear. ES mist reduced the number of CFU cultured from vocalized droplets to 90% of that seen in the control stamp smear. Pretreating the test plate with biomass smoke particles reduced the number of CFU cultured from vocalized droplets to 85–99% of that seen in the control stamp smear (Figure 2). Thus, both smoke particles in the air and smoke particles that had been coated onto the test plates reduced the numbers of bacteria in vocalized droplets; i.e., biomass smoke had both offensive and defensive antibacterial effects.

ES gargling for oropharyngeal decontamination (Figure 3).
Compared with that seen in the control droplets, the number of CFU cultured from vocalized droplets was reduced by >99% by gargling ES once, and it was suppressed by >99.9% by gargling ES 10 times. The effects of ES gargling on oral hygiene were maintained for several days.

Discussion

The prevalence of community-acquired pneumonia among elderly Japanese people has been increasing since the late 1970s [1], in spite of an increased prevalence of pneumococcal vaccine inoculation, advances in hygiene and sanitation techniques, and reductions in tobacco smoking. The prevalence of smoking has decreased from 80% in 1980 to 27% in males, and from 15% in 1980 to 8% in females [2]. The number of Buddhist housewives, who are routine users of incense sticks, in Japan also halved during the same period [3]. The reason why the prevalence of pneumonia has increased despite the fact that increased vaccine inoculation has caused a reduction in the prevalence of pneumococcal pneumonia is unclear. Furthermore, as baby boomers are joining the elderly generation the prevalence of pneumonia among the elderly is predicted to increase further.

Communal residences are associated with a high incidence of pneumonia. On the other hand, tobacco smoking did not increase the risk of pneumonia among our patients. In addition, from the viewpoint of airborne bio contamination spaces that allowed smoking were less contaminated than areas in which smoking was restricted. However, the examined residential spaces were generally clean; i.e., they were comparable to pharmaceutical cleanroom class C–D, according to the EU-GMP cleanliness classification.

Elderly people often need to have close conversations due to their poor hearing ability. Individuals who need nursing care can easily be exposed to droplet-borne infections during close conversations. Based on the number of bacteria individuals are exposed to, droplet-borne rather than airborne infections might be the main cause of community-acquired pneumonia. These findings suggested that droplet-borne infections that occur during conversations are a major cause of pneumonia, and biomass smoke might reduce the number of bacteria in vocalized droplets as well as airborne bio contamination.

Biomass burning is traditionally used for airborne decontamination, [6] including during pesticide use, Buddhist events, open fireplace for cooking, boiling and heating in a living room of old folk house (Irori in Japanese) and fire festivals (Goma-taki; exorcising evil spirits) in Japan and by native American medicine men [7]. Botanical smoke readily captures viruses or bacteria that are electrically charged negative and coated with lipid capsules [8] due to its physiochemical properties, including the antimicrobial effects of tar, the lipid affinity of such smoke particles, the effects of static electricity [9], and the Brownian motion of nanoparticles [10]. Biomass smoke has been used to decontaminate the air [7,11] since ancient times, when people burnt biomass for survival.

In Japan, the prevalence of smoking began to decrease in the late 1970s, and thereafter, the prevalence of pneumonia began to increase [1,2]. During the same period, the Buddhist population of Japan decreased to 35,000,000, which was half of that seen 4 decades earlier [3]. In addition, pesticide-containing incense sticks for use during mosquito season were replaced by liquid smokeless pesticides, as the prevalence of pneumoconiosis was found to be increased among people who worked with the powder used to produce incense sticks. Tobacco was also replaced by smokeless cigarette. The recent reduction in the amount of biomass smoke, including religion-related smoke, pesticide-containing smoke, and tobacco smoke, present in residential spaces might have been responsible for the increase in the prevalence of pneumonia. Smoke is a double-edged sword in that it acts as a disinfectant, but it can also irritate the airway and eyes [7]. However, apart from biomass smoke, there is no satisfactory method for airborne or skin decontamination in indoor spaces during active human use [6,12,14]. Our covering areas for medical treatment are regional middle-class mercantile cities, and traditional life style is still conserved. The current prevalence of COVID-19 positive was 50~70/100,000 populations in our area, while that was 1000/100,000 in big cities of Japan. (Yamaguchi Prefectural Reports of COVID-19 on January 22, 2021) Biomass smoke is a silent protector from environmental bio contamination.

Warm ES solution is our first-choice disinfectant for preoperative skin, oral-cavity, and upper-airway hygiene, including for preventing surgical site infections; i.e., we use it as an alternative to ethanol or povidone iodine [5]. ES is a novel disinfectant that acts against viruses, bacteria, and fungi except spore forming bacteria [5], and it exhibits equivalent antimicrobial activity to 70–80% ethanol and has no adverse effects on the human body or the environment because it is immediately converted to water after coming into contact with an organism [5,15,16]. ES solution promptly suppressed flu pharyngitis and labial herpes in a few days. (Not published) The antimicrobial mechanism of ES is based on the effects of hypochlorite and superoxide [8,15] under a super acidic state (pH 2.2–2.8). A super acidic state conveys hydrolipid affinity and surfactant effects on ES solution (Figure 4). Due to its lipid affinity, ES instantly captures and disinfects phospholipid-coated microorganisms [8,15]. ES solution has offensive antimicrobial activity, while biomass smoke has both offensive and defensive effects against microorganisms. However, the antimicrobial effects of gargling with ES were maintained for a few days. Among current disinfectants, ES solution is the only one that can be used for virucidal or bactericidal decontamination of the human body [14,16]. The process used to produce ES solution is quite simple; i.e., it involves the electrolyzation of 0.1% salt and tap water [15,16]. Also, the associated production costs are quite low; i.e., it costs approximately 1 US dollar to produce 100 liters of ES. In addition, ES generators are widely used for hospital sanitation and for rinsing fresh vegetables, seafood, and flowers in Japan; therefore, the immediate mass-volume production of ES solution is feasible [17]. The on-demand use of ES gargling might suppress droplet-borne infections in residential spaces, including quarantine and bioterrorism sites.

A field survey examining the practical use of biomass smoke and ES solution against pneumonia epidemics is required.

Conclusions

Smokeless residential environment might be responsible to the increase in prevalence of community-acquired pneumonia. ES might reduce the recent increase in the prevalence of epidemic pneumonia.

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