

## REPRINT

# Can the use of assistive technology and interactive therapeutic robots in nursing homes contribute to the spread of infectious disease?

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## ABSTRACT

**Background:** There is an increasing use of assistive technology and interactive therapeutic robots in nursing homes. However, little is known about the possible risks for transmitting infectious diseases through the use of such devices.

**Methods:** Representative surface samples of two multipurpose hygiene chairs and two interactive therapeutic robots were collected on a weekly basis at two nursing homes over a period of two months.

**Results:** We found that both robots and hygiene chairs may contribute to pathogen transmission.

## KEY WORDS

Assistive technology, interactive therapeutic robots, HAI, multipurpose hygiene chairs, nursing home

## BACKGROUND

Norwegian municipalities are increasingly using assistive technology and interactive therapeutic robots in their nursing homes [1]. Some of these products come in close physical and protracted contact with several patients and might constitute a source of infection. Little is known about the possible risks for transmitting infectious diseases through these devices. In this study we focused on multipurpose hygiene chairs and PARO interactive therapeutic robots.

Multipurpose hygiene chairs are used for washing and cleaning routines that require assistance from nursing staff (Figure 1).

PARO robots (Figure 2) are used in dementia care [2] to stimulate patients and cleaning done by the nursing home staff can only be done in a superficial way. Washing the interactive robot is not possible so that the artificial fur needs to be replaced by the distributor.

We collected representative surface samples of two hygiene chairs and two robots on a weekly basis over a period of two months at two nursing homes and analyzed the samples for the presence of clinically relevant microorganisms.

## MATERIAL & METHODS

### Nursing homes

Two nursing homes of approximately the same size, but located in different municipalities and with slightly different management structures took part in the study. Both nursing homes have implemented infection control programs.

### Multipurpose hygiene chairs and PARO robots

Four hygiene chairs (Carendo, ArjoHuntleigh, Sweden), two in each nursing home, were labeled according to the following scheme NxCx (N for nursing home 1 or 2, C for chair 1 or 2). N1C1 was not in use, due to necessary maintenance, but served as reference. N2C2 had been used by one resident only. N1C2 and N2C1 were in use by more than one resident, and no special precautions other than visible cleaning have been done. All hygiene chairs were visible clean according to applied standards [3] before sampling.

Four PARO robots, two in each nursing home, labeled NxPx (N for nursing home 1 or 2, P for robot 1 or 2). N1P1 and N1P2 were in sporadic use during the sampling period. For all PARO robots, there was no cleaning performed between the use by different residents.

**Conflicts of interest:** None to report.

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**FIGURE 1:** Multipurpose hygiene chair Carendo, ArjoHuntleigh  
[from: <http://www.arjohuntleigh.com/products/hygiene-systems/showering/shower-chairs/carendo/> ]



**FIGURE 2:** PARO interactive therapeutic robot in close contact with resident



### Swab sampling

Sterile flocked swabs were moistened in sterile water prior to surface swabbing of approximately 100 cm<sup>2</sup>. Two duplicate samples were taken each time and stored in either sterile water for bacterial cultivation or RNAlater for PCR analysis respectively.

Duplicate surface samples were taken with the M40 Transport system for bacterial cultivation.

### ATP analysis

Duplicate ATP surface samples were taken according to the manufacturer's protocol (Hygiena, UltraSnap™ surface test).

### Contact sampling with dry nutrient medium plates

Duplicate surface contact samples were taken with Rida®Count test plates for total bacteria and *Staphylococcus aureus* counts.

### MRSA

*Staphylococcus aureus* colonies from Rida®Count *Staph. aureus* test plates were transferred to MRSASelect™ agar (BioRad).

### Bacteriology from swab samples

Duplicates swab samples were pooled and transferred to the following selective media:

- **E. coli/coliform and ESBL detection:** Brilliance E.coli/coliform selective Agar and ESBL agar (Oxoid).
- **Enterococci and VRE:** HiCrome™ Rapid Enterococci agar, VancoScreening Brain Heart Infusion agar (NordicAST).

- **MRSA:** Samples were grown for 48 hours in PHMB enrichment broth without ceftoxitin, [4] and screened for MRSA. Results have been validated by PCR [5].
- **Clostridium difficile:** Samples were grown anaerobically in CCFT-broth [6] and plated on Braziers *Clostridium difficile* selective agar, after two and ten days. Results have been validated by PCR [7].

Antibiotic resistant strains were identified by MALDI-TOF MS Biotyper (Bruker Daltonik, Germany).

### PCR

qPCR was performed for influenza A and norovirus 1 and 2 were done as described in [8].

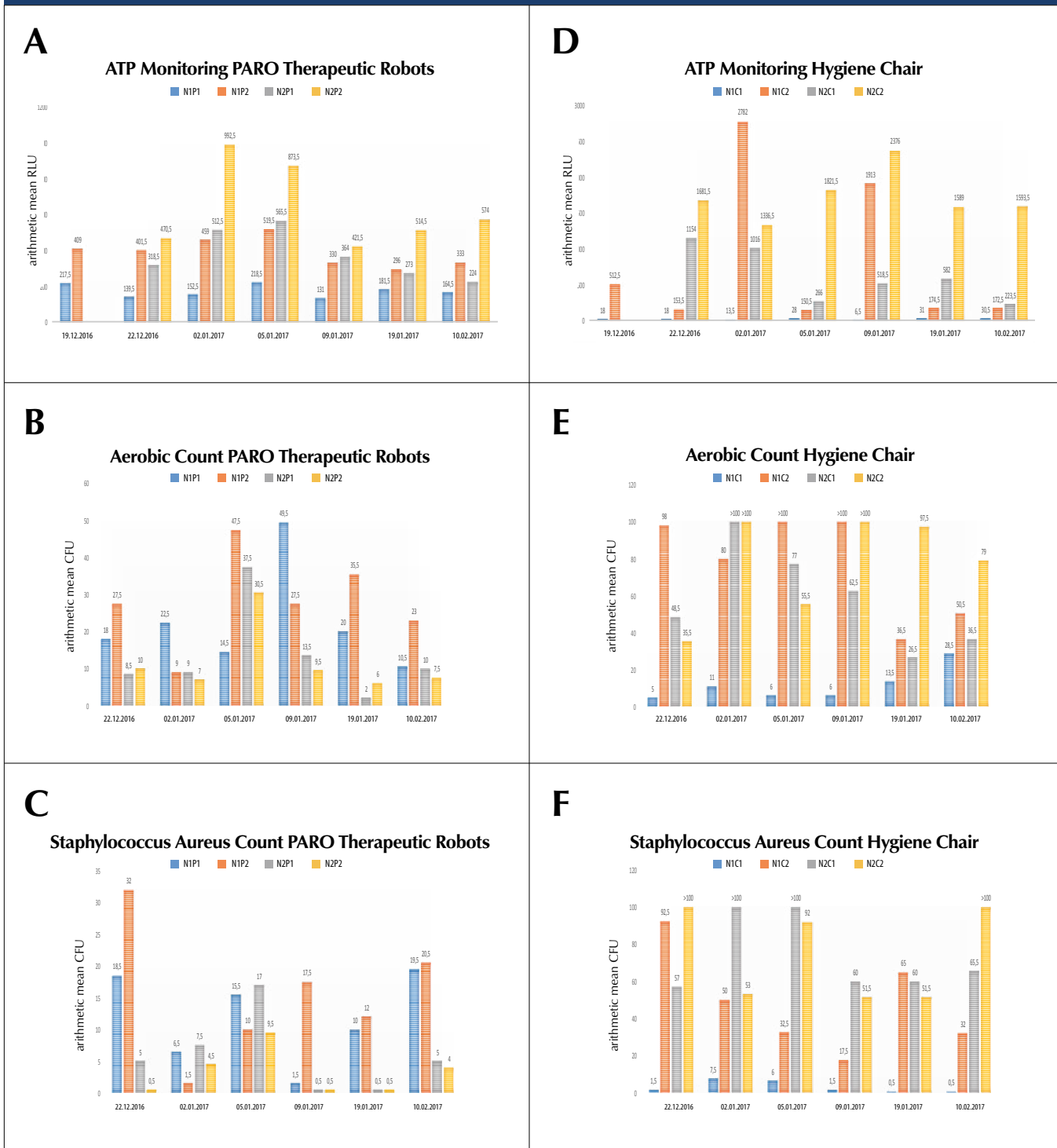
### RESULTS

PARO robots N1P1 and N1P2 were not in daily use, which could explain the lower arithmetic mean relative light units (RLU) values, i.e., luciferase activity, compared to the frequently used N2P1 and N2P2 (Figure 3, a). By contrast, N1P1 and N1P2 gave higher arithmetic mean CFU for both aerobic (Fig. 3, b) and *Staphylococcus aureus* counts (Fig. 3, c).

One sampling of N2P2 gave a single atypical colony on the MRSASelect™ agar. This colony was subsequently identified as methicillin resistant *Staphylococcus epidermis* by MALDI-TOF.

The hygiene chair N1C1 was not in use at the time of testing which may explain the results of the ATP monitoring. However the aerobic count had an arithmetic mean CFU/ml up

**FIGURE 3: Serial measurements (mean values) of ATP (a,d), aerobic counts (b,e) and *Staphylococcus aureus* counts (c,f) for PARO robots (a,b,c) and hygiene chairs (d,e,f).**



to 28.5 (Fig. 3). All other Hygiene chairs were sampled after standard cleaning. These showed both a high aerobic count (Fig. 3, e), as well as a higher degree of contamination with *Staphylococcus aureus* (Fig. 3, f). Furthermore, the ATP monitoring (Fig. 3, d) revealed that biological contamination in nursing home two was higher overall than in nursing

home one. One Rida®Count sampling of N2C1 gave typical colonies for MRSA on the MRSASelect™ agar. The latter was, however, not validated by other methods. Coliform bacteria (Table 1) were found on all four robots. N1P1 tested positive for *Enterobacteriaceae* at one sampling (Table 1, N1P1).

**TABLE 1: Result of selective bacterial cultivation. (-) no growth, (\*) no growth of *Enetrobacteriaceae*, but cefotoxitin resistant *Pseudomonas fulva* and *Pseudomonas putida*, (\*\*) *Enterococcus casseliflavus***

**N1P1**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
19.12.16	-	-	-	-	-
22.12.16	-	-	-	+	-
02.01.17	-	-	-	-	-
05.01.17	-	-	-	-	-
09.01.17	-	-	-	-	-
19.01.17	-	-	-	-	-
10.02.17	-	+++	-	-	-

**N1P2**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
19.12.16	-	-	-	-	-
22.12.16	-	+++	-	-	-
02.01.17	-	+++	-	-	-
05.01.17	-	++	-	-	-
09.01.17	-	+	-	-	-
19.01.17	-	-	-	-	-
10.02.17	-	-	-	-	-

**N2P1**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
22.12.16	-	-	-	-	-
02.01.17	-	++	-	-	-
05.01.17	-	++	-	-	-
09.01.17	-	-	-	-	-
19.01.17	-	+	-	-	-
10.02.17	-	-	-	-	-

**N2P2**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
22.12.16	-	-	-	-	-
02.01.17	-	+++	-	-	-
05.01.17	-	++	-	-	-
09.01.17	-	-	-	-	-
19.01.17	-	-	-	-	-
10.02.17	-	++	-	-	-

**N1C1**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
19.12.16	-	-	-	-	-
22.12.16	-	-	-	-	-
02.01.17	-	-	-	-	-
05.01.17	-	-	-	-	-
09.01.17	-	-	-	+	-
19.01.17	-	-	-	-	-
10.02.17	-	-	-	-	-

**N1C2**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
19.12.16	-	+++	-*	+++	-
22.12.16	-	++	-*	+++	-
02.01.17	++	++	-*	+++	-
05.01.17	-	-	-	-	-
09.01.17	-	+++	-*	+++	-
19.01.17	-	-	-	-	-
10.02.17	-	-	-	-	-

**N2C1**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
22.12.16	(+)	-	-*	-	-
02.01.17	-	-	-	-	-
05.01.17	-	(+)	-*	+	+++
09.01.17	-	-	-	+	+++
19.01.17	-	-	-	-	-
10.02.17	-	-	-	-	-

**N2C2**

Dato	<i>E.coli</i>	Colif.	ESBL	Entero	VRE
11.12.16	-	-	-	++	-
02.01.17	-	-	-	-	-
05.01.17	-	-	-	-	-
08.01.17	-	-	-	-	-
09.01.17	-	-	-	-	-
19.02.17	-	-	-	+	-
10.02.17	-	-	-	++	-

Except for N1C2, all hygiene chairs showed little or no *E. coli* or other coliform bacteria (Table 1). N2C2 tested positive for *Enterobacteriaceae*. Cefoxitin resistant *Pseudomonas fulva* and *Pseudomonas putida* were found on samples obtained from N2C1 and N1C2. N2C1 tested positive for a vancomycin-resistant enterococci (VRE), namely *Enterococcus casseliflavus* (Table 1).

None of the samples tested positive for viral nucleic acid or *Clostridium difficile*.

## DISCUSSION

This study has several limitations, such as the sample size, duration and number of participating nursing homes. However, the authors believe that this study gives an indication of the possible role that assistive technology and interactive therapeutic robots have in the transmission of microorganisms and that further research in this field is required to increase patient safety in nursing homes.

PARO robots are often used by several residents and shared between different nursing home sections. It is difficult to clean the artificial fur; it can only be removed and washed by the distributor. However, based on ATP monitoring and aerobic count (Fig. 3, a and b) it seems that bacteria do not long remain viable on the PARO. Nevertheless, it seems also that the PARO robot may be a beneficial environment for *Staphylococcus aureus* (Fig. 3, c). Further studies are needed to confirm this.

The finding that biological contamination in nursing home two was higher overall than in nursing home one, may be due to different managerial structures of the cleaning services. Cleaning in nursing home one is done by municipal employees only working in this particular nursing home, whereas cleaning personnel in nursing home two is done by employees working in different municipal institutions.

The presence of coliform bacteria (Table 1) on the fur of the PARO robot may be due to inadequate hand hygiene [9], and could indicate that the robot is contributing in the transfer of microorganisms between different patient zones.

The hygiene chairs showed a high level of bacterial contamination, even after standard cleaning. Interestingly, N1C1 which was not in use showed an increase in the aerobic count. This may indicate that the rough surface structure of the hygiene chairs may accumulate airborne bacteria. In general, this study has shown that current cleaning procedures for hygiene chairs are not adequate. One of the chairs in this study, N1C2, used by several residents, tested positive for cefotaxime-resistant *P. fulva* and *P. putida*.

That influenza virus, norovirus and *Clostridium difficile* were not found may be due to unrelated factors. The national peak of influenza virus infections in Norway was in week 51 [10], three weeks before the first samples were taken. Furthermore, there were no ongoing infections in the nursing homes related to these agents and there have been only 46 clinical CDI cases in 2016 in the municipalities where the two nursing homes are located.

This study demonstrate the need for further research on the role of assistive technology and interactive therapeutic robots in pathogen distribution and the need for new cleaning procedures, a constant evaluation of infection control systems, as well as improved product design.

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