Health Care of the Russian Federation · Volume 69 · Issue 3 · 2025
Original article. https://doi.org/10.47470/0044-197X-2025-69-3-246-254

ПРОФИЛАКТИКА ИНФЕКЦИОННЫХ ЗАБОЛЕВАНИЙ

PREVENTION OF INFECTIOUS DISEASES

Читать онлайн
Read online

Nouha Ketata[1], Yosra Mejdoub[1], Salma Maalej[2], Imen Turki[3], Ben Jmaa Maissa[1], Salma Smaoui[2], Baklouti Mouna[1], Jihen Jdidi[1], Ferièle Messadi-Akrout[2], Sourour Yaich[1]

Study of bacterial contamination of smartphones owned by health sciences students at the university teaching hospitals of southern Tunisia

[1]Hedi Chaker University Hospital, University of Sfax, Republic of Tunisia;
[2]Pharmacy University, University of Monastir, Republic of Tunisia;
[3]University of Sousse, Republic of Tunisia

ABSTRACT

Introduction. Smartphones (SP) of health-care-workers and trainees could be easily and quickly contaminated by pathogens.
The purpose of the study. To evaluate effectiveness of the disinfection with 70% isopropyl alcohol (IPA) on SP contamination, identify the prevalence of bacterial contamination of SP used by health sciences students at Sfax, Southern Tunisia and to delineate its associated factors.
Materials and Methods. It was a prospective, pre-post quasi-experimental study in the Institute of Nursing Sciences of Sfax to assess SP' contamination before and after disinfection with 70% IPA conducted between September and November 2021 among 100 trainees in the clinical services of the two University Hospital Centers of Sfax, Southern Tunisia (Habib Bourguiba Hospital and Hedi Chaker Hospital) and who were carrying SP during their internship.
Results. A total of 100 enrollees were included in the survey. The mean age was 20.37 ± 0.7 years. There were 58 (58%) females giving a male-to-female ratio of 0.72. The contamination rate of SP was of 62% among participants. Associated factors of SP contaminations were the 3rd year level (OR = 2.6; $p = 0.049$), working at a pediatric ward (OR = 2.7; $p = 0.042$), working at intensive care unit (OR = 3.2; $p = 0.018$) and working at Habib Bourguiba University Hospital (OR = 2.5; $p = 0.026$). Isolated germs were coagulase negative *Staphylococci* (79%), followed by *Bacillus* spp. (42%), *Micrococcus* spp. (29%), *Corynebacterium* spp. (11.3%) and gram-negative-bacilli of the environment (6.4%). Disinfection with 70% IPA had proven to be effective, as it had allowed a reduction rate of 96.25% of the growth of germs.
Research limitations. It included the cross-sectional design, through which it was possible to assess only the association between facts, but not to confirm causal relationships and temporality.
Conclusions. High level of bacterial contamination of trainees' SP was observed causing high risk for pathogens spread. The surface spread method using 70% IPA seem to be simple, effective and riskless for SP disinfection.

Keywords: *contamination; disinfection; healthcare associated infections; smartphones*

Compliance with ethical standards. The study does not require submission of the opinion of the biomedical ethics committee or other documents.

For citation: Nouha Ketata, Yosra Mejdoub, Salma Maalej, Imen Turki, Ben Jmaa Maissa, Salma Smaoui, Baklouti Mouna, Jihen Jdidi, Ferièle Messadi-Akrout, Sourour Yaich. Study of bacterial contamination of smartphones owned by health sciences students at the university teaching hospitals of southern Tunisia. *Zdravookhranenie Rossiiskoi Federatsii / Health Care of the Russian Federation, Russian journal.* 2025; 69(3): 246–254. https://doi.org/10.47470/0044-197X-2025-69-3-246-254 https://elibrary.ru/oafwlk

For correspondence: *Ketata Nouha,* e-mail: ketatanouha@gmail.com

Contribution of the authors: *Nouha Ketata, Yosra Mejdoub, Imen Turki, Jihen Jdidi, Sourour Yaich* — research concept and design, data collection, processing, and analysis, writing, and editing; *Salma Maalej, Ben Jmaa Maissa, Salma Smaoui, Baklouti Mouna, Ferièle Messadi-Akrout* — research concept and design, data collection, processing, and analysis. *All co-authors* – approval of the final version of the article, responsibility for the integrity of all parts of the article.
Funding. The study had no sponsorship.
Conflict of interest. The authors declare no conflict of interest.

Received: August 29, 2023 / Accepted: March 19, 2024 / Published: June 30, 2025

Оригинальная статья. https://doi.org/10.47470/0044-197X-2025-69-3-246-254

Профилактика инфекционных заболеваний

Кетата Н.[1], Меджду Й.[1], Маалей С.[2], Турки И.[3], Джмаа Б.М.[1], Смауи С.[2], Baklouti M.[1], Ждиди Дж.[1], Мессади-Акрут Ф.[2], Яич С.[1]

Исследование бактериального загрязнения смартфонов, принадлежащих студентам медицинских факультетов в университетских клиниках южного Туниса

[1]Университетская больница Хеди Чакер, Сфаксский университет, 3000, Сфакс, Республика Тунис;

[2]Фармацевтический университет, Монастирский Университет, 5000, Республика Тунис;

[3]Суский Университет, 4002, Республика Тунис

РЕЗЮМЕ

Введение. Смартфоны, используемые медицинскими работниками и стажёрами, подвержены высокому риску загрязнения патогенами.
Цель исследования — оценить эффективность дезинфекции загрязнённых смартфонов 70% изопропиловым спиртом (ИПС), определить распространённость бактериального загрязнения смартфонов, используемых студентами медицинских вузов в Сфаксе, Южном Тунисе, и установить связанные с этим факторы.
Материал и методы. В Институте сестринского дела Сфакса для оценки загрязнения смартфонов до и после дезинфекции 70% ИПС в период с сентября по ноябрь 2021 г. проведено проспективное, пред-постквазиэкспериментальное исследование с участием 100 стажёров в клинических службах двух университетских больничных центров Сфакса, Южный Тунис (больница Хабиба Бургибы и больница Хеди Шакера).
Результаты. Всего в опросе приняли участие 100 человек. Средний возраст составил 20,37 ± 0,70 года. Среди них было 58 (58%) женщин при соотношении мужчин и женщин 0,72. Уровень загрязнения смартфонов составил 62%. Сопутствующими факторами заражения смартфонов были 3-й год обучения (OR = 2,6; p = 0,049), работа в педиатрическом отделении (OR = 2,7; p = 0,042), работа в отделении интенсивной терапии (OR = 3,2; p = 0,018) и работа в университетской больнице Хабиба Бургибы (OR = 2,5; p = 0,026). Были выделены штаммы коагулазоотрицательных стафилококков (79%), *Bacillus* spp. (42%), *Micrococcu*s spp. (29%), *Corynebacterium* spp. (11,3%) и грамотрицательные бактерии в окружающей среде (6,4%). Дезинфекция 70% ИПС оказалась эффективной, поскольку она позволила снизить темпы роста микробов на 96,25%.
Ограничения исследования. Оно включало поперечное сечение, с помощью которого можно было оценить только связь между фактами, но не подтвердить причинно-следственные связи и динамику заражения.
Заключение. Высокий уровень бактериального загрязнения смартфонов у студентов приводит к высокому риску распространения патогенов. Метод обработки поверхности смарфонов 70% ИПС представляется простым, эффективным и безопасным для дезинфекции смартфонов.

Ключевые слова: *загрязнение; дезинфекция; связанные с оказанием медицинской помощи инфекции; смартфоны*

Соблюдение этических стандартов. Исследование не требует представления мнения комитета по биомедицинской этике или других документов.

Для цитирования: Кетата Н., Меджду Й., Маалей С., Турки И., Джмаа Б.М., Смауи С., Баклути М., Ждиди Дж., Мессади-Акрут Ф., Яич С. Исследование бактериального загрязнения смартфонов, принадлежащих студентам медицинских факультетов в университетских клиниках южного Туниса. *Здравоохранение Российской Федерации*. 2025; 69(3): 246–254. https://doi.org/10.47470/0044-197X-2025-69-3-246-254 https://elibrary.ru/oafwlk

Для корреспонденции: *Ketata Houna*, e-mail: ketatanouha@gmail.com

Участие авторов: *Кетата Н., Меджду Й., Турки И., Ждиди Дж., Яич С.* — концепция и дизайн исследования, сбор, обработка и анализ данных, написание текста, редактирование; *Маалей С., Джмаа Б.М., Смауи С., Баклути М., Мессади-Акрут Ф.* — концепция и дизайн исследования, сбор, обработка и анализ данных. *Все соавторы* — утверждение окончательного варианта статьи, ответственность за целостность всех частей статьи.
Финансирование. Исследование не имело спонсорской поддержки.
Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов в связи с публикацией данной статьи.

Поступила: 29.08.2023 / Принята к печати: 19.03.2024/ Опубликована: 30.06.2025

Health Care of the Russian Federation · Volume 69 · Issue 3 · 2025
Original article. https://doi.org/10.47470/0044-197X-2025-69-3-246-254

Introduction

The first cellular phone call worldwide was on April 3, 1973 [1]. Then, modern technology had rapidly contributed to develop technologies for individual and common use [2]. Thus, this technological improvement had drastically change personal as well as professional lives particularly with appearance of smartphones (SP) [1]. Similarly, to other fields, the medical domain experienced the resounding effects of the SP with a profound impact as it became one of the most indispensable accessories of professional and social life [1, 3]. Afterwards, the use of SP had been banned in some health care facilities because of their electromagnetic interference with medical equipment [4]. Then, it was found that the interference hypothesis was not well established with a resurgence of interest in the use of SP. Consequently, SP had become a widely used accessory in the hospital setting and healthcare professionals refer to SP as a means of communication and a source of information [1, 4]. In addition, SP use requires keeping them close to different parts of the body: the face, nose, mouth, ears and hands, which are colonized by germs and are sources of infection [5]. Repetitive hand contact, as well as the temperature generated by the SP itself, creates an environment conducive to the growth of germs, which are normally present on the skin [6]. Thus, SP seem to be a perfect habitat for colonization by several pathogens [7] particularly in healthcare settings where they could be easily and quickly contaminated by pathogens from the hospital environment, patients, and medical devices [8]. Then, constant use of SP by healthcare workers and trainees in different care facilities, particularly with the lack of disinfection, make them potential routes for pathogens transmission including multi-drug-resistant organisms [3, 7]. Consequently, SP could be incriminated in healthcare associated infections (HAI) [1–3, 7, 8] which are one of major concern for healthcare systems around the world and are significantly associated with higher rates of morbidity and mortality as well as increased hospitalization costs [9]. According to the World Health Organization (WHO), HAI occur in 7 out of every 100 hospitalized patients in developed countries and in 10 to 15 per 100 patients in developing countries [9]. In southern Tunisia, prevalence of HAI was 9.02% in South Tunisian University Hospitals in 2019 [10]. Furthermore, the incrimination of SP in transmission of HAI have been demonstrated in various studies worldwide [9, 11, 12]. A previous study came to a result that pathogenic bacteria are present on approximately 40% of patients' SP and on approximately 20% of hospital staff' SP [13]. A particular attention should be paid for students and trainees while performing internships at hospitals. Their frequent use of SP in several sites raises the opportunity for cross-contamination, especially if no safety practices are common among them [14]. In light of what was mentioned and the scarcity of data assessing contamination of SP in healthcare facilities in Tunisia, the present study aimed to evaluate effectiveness of the disinfection with 70% IPA on SP contamination, identify the prevalence of bacterial contamination of SP used by health sciences students (HSS) at the two University Hospitals Centers of Southern Tunisia (Habib Bourguiba University Hospital: HBUH and Hedi Chaker University Hospital: HCUH) and to delineate associated factors of bacterial contamination of SP.

The purpose of the study. To evaluate effectiveness of the disinfection with 70% isopropyl alcohol (IPA) on SP contamination, identify the prevalence of bacterial contamination of SP used by health-sciences-students at Sfax, Southern-Tunisia and to delineate its associated factors.

Methods

Study design. It was a prospective, pre-post quasi-experimental study conducted in the Institute of Nursing Sciences of Sfax to assess SP' contamination before and after disinfection with 70% IPA. It was over a period of three months: September, October and November 2021.

Study population. All students enrolled in the 2nd and the 3rd year levels during the academic year 2021–2022, who were trainees in the clinical services of the two University Hospital Centers of Sfax, Southern Tunisia (HBUH and HCUH) and who were carrying SP during their internship were eligible to participate in the present survey. Inclusion criteria covered students enrolled in the Institute of Nursing Sciences of Sfax (2^{nd} and 3^{rd} year levels) who willed to participate in the study. Exclusion criteria were being enrolled in the first academic year because they had not to be trainers in Sfax University Hospitals. Non-inclusion criteria were not accepting to participate in the survey or students who were absents the day of survey.

Data collection procedure. The study protocol was rigorously written, with clear and precise objectives by expert teams. After reviewing literature, a French self-administered questionnaire divided into three sections was standardized then distributed. The first section addressed general information of enrollees such as age, gender, academic year and previous training in intensive care unit. The second part gathered information on SP use (seniority, frequency and causes of SP usage). Finally, the third part assessed the SP hygiene such as information about necessity of disinfection, frequency and product used for disinfection as well as hand hygiene after SP use and culture results were later announced.

The first step was to collect data from questionnaires distributed to enrollees. Then, samples from the SP were taken before and after disinfection as mentioned below. Samples were identified by marking the same number on the swab and the corresponding information card. Pre-disinfection and post-disinfection swabs were distinguished by marking them with the index "a" for pre-disinfection swabs and "b" for post-disinfection swabs. Besides, the two swabs had the same number for the same SP. The samples were sent rapidly to the regional hygiene laboratory in a cool box containing an ice pack, for analysis. Afterwards, identification was based in colony morphology, gram staining and biochemicals reactions.

After applying hydro-alcoholic gel on hands and wearing gloves, the samples were taken with sterile swabs dampened with sterile physiological serum. The swab was taken from the entire surface of the SP likely to be in contact with the hands (screen and back surface), making tight striations in three directions: horizontally, vertically and diagonally, and turning the swab to load it with as many germs as possible. Then the intervention to evaluate was the disinfection with 70% IPA. It was performed using 70% IPA sprayed on a sterile microfiber cloth. We have waited two minutes, the time for the disinfectant to be effective. Then, sample was recollected again according to the same modality. On receipt, the swabs were separated to distinguish those made before disinfection from the ones made after. Each swab was discharged into 0.5 ml of sterile saline. The resulting suspension was inoculated on different culture media which were prepared according to the laboratory's recommendations. Inoculation was done by a calibrated loop using the four-quadrant inoculum depletion technique. After 48 hours, the cultures were observed. The colonies that appeared were counted, identified and noted. Identification was based on the appearance of the colonies as

Table 1. General characteristics

Таблица 1. Общая характеристика

Variables Переменные		Number of participants Число участников	
		n	%
Enrollees data | *Сведения об участниках исследования*			
Gender Пол	male | мужской	42	42
	female | женский	58	58
Age Возраст	< 20 years | лет	62	62
	≥ 20 years | лет	38	38
Academic year Срок обучения	2nd year | 2-й год	68	68
	final year | последний курс	32	32
Hospital of training Стажировка в клинике	Habib Bourguiba University Hospital | Клиника Университета Хабиб Бургиба	71	71
	Hedi Chaker University Hospital | Клиника Университета Хеди Чакер	29	29
Ward of training Место стажировки	pediatric ward | детское отделение	17	17
	adult ward | терапевтическое отделение	83	83
Ward of training type Профиль стажировки	medical | терапевтическое отделение	25	25
	surgical | хирургическое отделение	65	65
	intensive care unit отделение интенсивной терапии	10	10
	previous training in intensive care unit предыдущая стажировка в палате интенсивной терапии	23	23
SP information | *Сведения о смартфонах*			
Seniority of actual SP Срок использования данного смартфона	< 6 months | мес	13	13
	6–12 months | мес	29	29
	1–2 years | лет	5	5
	> 2 years | лет	53	53
Frequency of SP use Частота использования смартфона	< 2 times/day | раз в день	0	0
	2–5 times/day | раз в день	20	20
	6–20 times/day v раз в день	37	37
	> 20 times/day | раз в день	43	43
Causes of SP use at hospital Причины использования смартфона в клинике	surfing on internet | поиск в интернете	63	63
	responding calls | ответ на входящие звонки	55	55
	using applications | использование приложений	41	41
	chronometer, calculator | хронометр, калькулятор	14	14
Frequency of SP disinfection Частота дезинфекции смартфона	no disinfection | без дезинфекции	57	57
	1 time/semester | раз в семестр	7	7
	1 time/month | раз в месяц	10	10
	1 time/week | раз в неделю	15	15
	after each use | после каждого использования	11	11
Product used for SP disinfection Средство для дезинфекции смартфона	hydroalcoholic gel | водно-спиртовой гель	51	51
	wipes | влажные салфетки	22	22
	alcohol solution | спиртовой раствор	14	14
	bleach | отбеливающее средство	2	2
	hand hygiene after SP use гигиеническая обработка рук после использования смартфона	19	19

Health Care of the Russian Federation · Volume 69 · Issue 3 · 2025
Original article. https://doi.org/10.47470/0044-197X-2025-69-3-246-254

Table 2. Culture results after 48-hours incubation

Таблица 2. Результаты микробиологического анализа после инкубации в течение 48 ч

Isolated germs Выделенные штаммы	Number of samples Количество образцов	Positives cultures, % Положительные посевы, %
CNS | Коагулаза-негативные стафилококки	49	79
Bacillus spp.	26	42
Micrococcus spp.	18	29
Fungi | Грибы	15	24.2
Corynebacterium spp.	7	11.3
Gram-negative bacilli in the environment Грам-отрицательные бактерии в окружающей среде	4	6,4

well as Gram staining followed by immersion microscopy and other standard chemical reactions. Indeed, the colonies whose microscopic study showed Gram-positive cocci were tested for catalase and DNAse.

Statistical analysis. Data analysis was performed using the Statistical Package for Social Sciences (SPSS) computer software in its 20th version. We checked the normality of the distribution of the quantitative variables, by the Kolmogorov–Smirnov test and the Shapiro–Wilk test. Descriptive analysis was performed for quantitative data by mean, standard deviations for normally distributed variables and by median and interquartile range for non-normally distributed variables. For qualitative data, frequencies and percentages were used as applicable. A Univariate regression analysis was performed to predict potentially significant determinants of positive culture of SP. A p-value of < 0.05 was considered statistically significant.

Ethical consideration. An oral and confirmed consent was obtained from all participants. It had been approved by the regional ethical committees. Samples from the SP were taken by an authorized and well-trained paramedical personnel. All samples were taken by the same person, according to an explained and written protocol and under the most aseptic conditions possible.

Results

Enrollees Data. Among a total of 197 HSS enrolled in the 2nd and the 3rd year during the 2021–2022 academic year, 100 enrollees accepted to participate in the survey giving a response rate of 50.7%. The mean age was 20.37 ± 0.70 years. There were 62 (62%) participants aged ≥ 20 years. Of the 100 trainees, 58 (58%) cases were female giving a male to female ratio of 0.72. There were 71 (71%) cases affected at Habib Bourguiba university hospital. According to the ward of training, there were 17 trainees assigned to a pediatric ward. Being affected at an intensive care unit was noted in 10 cases. There were 68 (68%) students enrolled in the 2nd year level. Of all, 23 (23%) enrollees had a training in intensive care unit previously (Table 1).

Smartphone Information. The seniority of the actual SP was above 2 years in 53 (53%) cases. Forty-three cases (43%) used their SP more than 20 times per day. Of all, 83% were using their SP during their internship. Surfing on internet to search clinical information was the main cause of use in 63% followed by responding calls in 55% and using applications in 41%. Of all participants, 39% were informed about necessity of SP disinfection before and after internship in hospitals. Regular disinfection of SP was noted in 43 (43%) cases. Of whom, 15 (15%) participants disinfected their SP 1 time per week. Hydroalcoholic gel was the main product used in 51% (n = 22). Only 19 (19%) students had the habit to disinfect their hand after SP use and 82 (82%) cases perceived that their SP could carry pathogens (**Table 1**).

Swab data: assessing contamination of smartphones. There were 62 % positive culture, indicating contamination of the SP. Among whom, 58% were poly-microbial. For isolated pathogens, the predominant germs were coagulase negative *Staphylococci* (CNS). They were isolated in 49 samples. *Bacillus* spp., *Micrococcus* spp., *Corynebacterium* spp., and gram-negative bacilli of the environment were present in 26, 18, 7, and 4 samples, respectively (**Table 2**).

After using 70% IPA the rate of culture positivity was 3%. The total growth reduction rate was 96.25%, with variability between the different germs isolated as shown in **Table 3**.

Associated factors of smartphone contamination (positive culture): Results of univariate analysis

Positive culture of SP was significantly associated with the 3rd year level (odds ratio (OR) = 2.6; p = 0.049), working at adult ward (OR = 2.7; p = 0.042), working at intensive care unit (OR = 3.2; p = 0.018) and working at Habib Bourguiba University Hospital (OR = 2.5; p = 0.026) (**Table 4**).

Table 3. Reduction rate of microbial growth after disinfection with 70% IPA

Таблица 3. Степень подавления роста бактерий после дезинфекции 70% изопропиловым спиртом

Germ Штаммы	Number of colony forming unit | Число КОЕ		Growth reduction rate, % Темпы подавления роста, %
	before disinfection до дезинфекции	after disinfection после дезинфекции	
CNS | Коагулаза-негативные стафилококки	150	1	99,3
Fungi | Грибы	102	13	87,25
Micrococcus spp.	64	1	98,43
Bacillus spp.	40	0	100
Corynebacterium spp.	31	0	100
Gram-negative bacilli in the environment Грам-отрицательные бактерии в окружающей среде	13	0	100

Table 4. Associated factors of SP contamination

Таблица 4. Факторы, связанные с инфекционным загрязнением смартфона

Variables Переменные		Positive culture Положительные посевы *n* (%)	Negative culture Отрицательные посевы *n* (%)	Crude OR (95% CI) Отношение шансов (95% ДИ)	*p*
Enrollees data | *Сведения об участниках исследования*					
Gender Пол	male | мужской	27 (64.3)	15 (35.7)	–	0.4
	female | женский	41 (70.7)	17 (29.3)	1.3 (0.5–3.0)	0.4
Academic year Срок обучения	2nd year level | 2-й курс	42 (61.8)	26 (38.2)	–	0.04
	3rd year level | 3-й курс	26 (81.3)	6 (18.8)	2.6 (1.1–7.4)	0.04
Ward of training Место стажировки	adult ward | терапевтическое отделение	60 (72.3)	23 (27.7)	2.7 (1.6–8.9)	0.04
	pediatric ward | детское отделение	8 (47.1)	9 (52.9)	–	0.04
	medical ward | терапевтическое отделение	12 (48)	13 (52)	1	0.02
	surgical ward | хирургическое отделение	47 (72.3)	18 (27.7)	1.7 (1.2–3.6)	0.02
	intensive care unit отделение интенсивной терапии	9 (90)	1 (10)	3.2 (1.6–6.5)	0.01
Hospital of training Стажировка в клинике	Habib Bourguiba University Hospital Клиника Университета Хабиб Бургиба	53 (74.6)	18 (25.4)	2.5 (1.4–8.0)	0.02
	Hedi Chaker University Hospital Клиника Университета Хеди Чакер	15 (51.7)	14 (48.3)	–	0.02
SP information | *Сведения о смартфонах*					
Frequency of daily SP use Частота использования смартфона:	< 20/day | сут	36 (63.2)	21 (36.8)	–	0.2
	≥ 20/day | сут	32 (74.4)	11 (25.6)	1.7 (0.7–4.0)	0.2
Information about necessity of SP disinfection Осведомлённость о необходимости дезинфекции смартфона	no | нет	42 (68.9)	19 (31.3)	0.9 (0.3–2.1)	0.8
	yes | да	26 (66.7)	13 (33.3)	–	0.8
Regular disinfection of SP Регулярная дезинфекция смартфона	no | нет	44 (65.7)	23 (34.3)	–	0.4
	yes | да	24 (72.7)	9 (27.3)	1.3 (0.5–3.5)	0.4
Hand hygiene after SP use Гигиеническая обработка рук после использования смартфона	no | нет	54 (66.7)	27 (33.3)	–	0.5
	yes | да	14 (73.7)	5 (26.3)	1.4 (0.4–4.3)	0.5

Discussion

Several studies were carried out in different countries to assess the bacterial contamination of SPs in hospitals or elsewhere. The collection protocol was by swabs in most cases. Sterile cotton swabs are the most commonly used for surface sampling [15]. According to a literature review conducted between 2005 and 2019 among 71 published studies on bacterial contamination of SP, 66 surveys used swabbing with a sterile cotton swab moistened with a saline solution [16].

To the best of our knowledge, this was the first survey conducted at local area evaluating SP use among HSS in Southern Tunisia. Our study targeted a young population with a mean age of 20 years. This age group had been associated in the published literature with excessive use of SP with high rates of SP dependence among them [17]. This was in line with our results finding 43% of enrollees using their SP more than 20 times per day.

Several studies have been conducted in healthcare facilities to assess contamination of staff' SP. The rate found in the present survey was 62% which was concordant with Olsen and al' findings of an average culture positivity rate of 68% [16]. Besides, it was lower than what was mentioned by Parul Dipak Shah et al. [18] and Canales MB et al. [19] finding respectively rates of 96% and 82% of mobile phone contamination.

The most isolated bacteria specie was coagulase negative *Staphylococci* in 79% of cases, which was consistent with literature data. In fact, an Indian survey reported a rate of 78% of isolated CNS [18]. Our rate was higher than findings from Saudi Arabia and united states showing rates of 52.8% and 75% respectively [7, 19]. Other studies had shown that isolated germs from SP and touch screens were in part germs of the normal human skin flora. A German survey found that Gram-positive cocci were among the most common germs isolated from SP [20]. Previously, there was a general consensus to classify the bacteria of the normal human flora as non-pathogenic germs. Besides, recently, clinical importance of these germs increased and their etiological role in certain community or nosocomial infections had been well established. They act as opportunistic or pathogenic germs, especially when transmitted to immunocompromised individuals [21]. In addition, normal human skin flora had expressed more resistance to antibiotics, which may complicate their management [21]. CNS are able to create a biofilm on inanimate surfaces, which could cause problems

particularly in patients receiving a valve prosthesis, implant or catheter [15]. Apart from CNS, *Bacillus* spp. were isolated in 42% of cases. The role of *Bacillus* spp. in the induction of infections had also been confirmed in the literature. A retrospective study was conducted in 2018 on samples of *Bacillus cereus* isolated in 9 hospitals in France [22]. These germs were responsible for localized infections in 8% of cases, and 72% of patients had *Bacillus cereus* bacteremia. In 62% of the cases, it was considered the etiological agent of infections and was managed by an adapted antibiotic therapy.

At the third place, micrococci were isolated in 29% of cases. These germs were also found in 27.7% of the studies published in this context [19]. These are environmental germs that have been incriminated in pulmonary infections, bacterial endocarditis and bacteremia after catheter infections. However, we did not isolate *Staphylococcus aureus*, although this germ was found in 91.5% of the studies concerning health care personnel [16]. *S. aureus* had been considered a marker of poor hygiene quality in health care facilities [23]. A previous Tunisian study in 2019 that targeted SP from students in order to characterize *Staphylococci* strains. It showed that *S. aureus* was isolated in 79.1% of studied devices and that their multiple antibiotic resistance index was ranging from 0.444 to 0.812 [23]. Since the contamination of the SP reflects the human skin flora, it can be concluded that the hands of the staff included in the present study are free of pathogenic germs. This could be explained by the habit of hand hygiene and SP disinfection introduced since the COVID-19 pandemic and reinforced by foundation of hygiene departments in university hospitals of Sfax.

Arriving to factors associated with positive culture of SP, this rate had no significative difference between males and females in this survey. Besides, higher rate of bacterial growth in male subjects was noted in the study conducted by Cicciarella Modica *et al.* [11]. Students of third year level had significantly higher rates of positive culture than those enrolled in second year. This result could be explained by the fact that older students should have harder trainees and more difficult tasks as they are at the final step of their academic career and they are preparing to start their professional experience. Thus, they are more exposed to have contaminated SP. In addition, working in intensive care unit was statistically associated with positive culture of SP. This result was previously supported by a Turkish survey [24]. Authors explained this result by the routine of patient body care given to patients in intensive care unit which could lead to higher contamination of hands and consequently of SP.

At the same context, working in adult ward was significantly associated with higher prevalence of positive culture. This fact was previously supported by an African survey showing lower prevalence of contamination in pediatric wards [9].

While many recommendations had been established for hand hygiene practice, the Centers for Disease Control and Prevention had recently introduced recommendations for fomite hygiene and disinfection (including SP) after the rapid emergence of COVID-19 pandemic [16]. Likewise, this practice is not yet adopted widely. Indeed, 67% of students of the present survey did not disinfect their SP regularly. This rate was higher than Iranian results showing that 28% of dental students never disinfected their phones [25]. In addition, Zaman and Helmi' survey, found that 8.75% of participants admitted never to disinfect their SP [21]. This rate variability between studies could be explained by the difference in the degree of awareness of the need for SP hygiene.

Generally, it is strongly recommended to daily disinfect SP, especially in healthcare settings. The disinfection procedure should involve an effective intervention that respects the nature of the screen's tactile surface [16].

Finally, we found that alcohol, as a disinfectant, reduces the detection of germs on the surface of the SP with a reduction rate of 96%. This result was previously supported by previous survey conducted among dental staff finding that the use of swabs moistened with 70% IPA had a significantly reduction of the contamination rate of SP with 98% of efficiency [25]. Although the use of wipes with chemicals could damage the SP screen, it had been noted that treatment with 70% IPA is a safe and simple mean of disinfection, resulting in membrane damage and rapid denaturation of the proteins, interfering with the metabolism of the microorganism causing bacterial lysis. At the same context, large technology companies such as Apple had updated recent guidelines on SP maintenance, suggesting that SP cleaning could be simply by application of 70% IPA or disinfecting wipe. In general, hydroalcoholic solutions are a better way to disinfect SP as they are effective and safe.

Recommendations and Conclusion

All objects with frequent hand contact, including SP, can serve as reservoirs. Thus, contamination of the healthcare workers' hands is a major factor in the transmission of healthcare associated infections at hospital environment, making it necessary to promote good hand hygiene in that environment [26]. At the same context, several studies have addressed the issue of hand contamination and its incrimination in infectious diseases transmission. The results were impressive. An Indian survey conducted on 2018 in which they assessed simultaneously the contamination of SP and the staff hands showed that the species from the SP and the dominant hand of the staff had the same bacterial species, suggesting the role of the hand in the transmission of germs over phones [18]. Thus, the established role of SP in the transmission of germs and the induction of healthcare-associated infections requires the implementation of prevention measures. Frequent hand hygiene as well as periodic and regular disinfection of SP will reduce the risk of transmission of potential pathogens [5].

In the context of preventing healthcare-associated infections, the WHO had stated that "in most cases, the hands of healthcare workers are the vehicle of transmission from source to patient". Therefore, hand hygiene is at the head of Standard Precautions list and is undoubtedly the most effective measure for infection control. Thus, health care workers should be aware of the need for good hand hygiene, either by washing or by rubbing with a hydroalcoholic disinfectant, in order to eliminate potentially pathogenic germs. Hand hygiene is indicated, after touching objects in the hospital environment, since these could be contaminated with germs. Nowadays, and after the emergence of COVID-19, the practice of hand hygiene had fortunately increased, especially since hydro-alcoholic products had shown their effectiveness against bacterial and viral germs. Hand rubbing is an effective and quick method (20 to 30 seconds according to the WHO). The guidelines and means for good hand hygiene should be within sight and reach of health care personnel to optimize this practice.

Given the causal role of SP in the spread of germs at hospital setting, and given that it is exposed to all types of environments, corresponding hygiene should be considered.

The use of the SP in the bathroom, even if followed by hand washing, may result in contamination by germs harbored by the SP and then by the hands. Therefore, this device should not be used in the toilet, bathroom, or other contaminated areas. The Centers for Disease Control and Prevention recently published guidance for cleaning frequently touched surfaces at home (such as SP) and indicated that if no cleaning product instructions were specified by the supplier, wipes or sprays containing at least 70% IPA should be used for disinfecting electronic devices. The awareness of the importance of disinfecting SP had prompted some companies such as Apple, Samsung and Google to introduce a guide for proper disinfection.

In conclusion, contaminated objects in a hospital environment are a source of germs involved in healthcare associated infections. The colonization of the health personnel' SP is a proven phenomenon and constituted one of the ways of transmission of germs towards hospitalized patients. In this context, the present study showed high level of bacterial contamination of trainees' mobile phones. The surface spread method using 70% IPA seem to be simple, effective and riskless for SP disinfection. Nevertheless, more regulations on the use of SP in healthcare settings is important in order to focus on this aspect, implement good practices and minimize the incidence of healthcare associated infections caused by incorrect handling of mobile devices.

REFERENCES / ЛИТЕРАТУРА

1. Ozdalga E., Ozdalga A., Ahuja N. The smartphone in medicine: a review of current and potential use among physicians and students. *J. Med. Internet Res.* 2012; 14(5): e128. https://doi.org/10.2196/jmir.1994
2. Morubagal R.R., Shivappa S.G., Mahale R.P., Neelambike S.M. Study of bacterial flora associated with mobile phones of healthcare workers and non-healthcare workers. *Iran. J. Microbiol.* 2017; 9(3): 143.
3. Mushabati N.A., Samutela M.T., Yamba K., Ngulube J., Nakazwe R., Nkhoma P., et al. Bacterial contamination of mobile phones of healthcare workers at the University Teaching Hospital, Lusaka, Zambia. *Infect. Prev. Pract.* 2021; 3(2): 100126. https://doi.org/10.1016/j.infpip.2021.100126
4. Ramesh J., Carter A.O., Campbell M.H., Gibbons N., Powlett C., Moseley H., et al. Use of mobile phones by medical staff at Queen Elizabeth Hospital, Barbados: evidence for both benefit and harm. *J. Hosp. Infect.* 2008; 70(2): 160–5. https://doi.org/10.1016/j.jhin.2008.06.007
5. Koscova J., Hurnikova Z., Pistl J. Degree of bacterial contamination of mobile phone and computer keyboard surfaces and efficacy of disinfection with chlorhexidine digluconate and triclosan to its reduction. *Int. J. Environ. Res. Public Health.* 2018; 15(10): 2238. https://doi.org/10.3390/ijerph15102238
6. McGoldrick M. Preventing the transfer of pathogenic organisms from the use of mobile phones. *Home Healthc. Now.* 2016; 34(1): 45. https://doi.org/10.1097/NHH.0000000000000330
7. Banawas S., Abdel-Hadi A., Alaidarous M., Alshehri B., Bin Dukhyil A.A., Alsaweed M., et al. Multidrug-resistant bacteria associated with cell phones of healthcare professionals in selected hospitals in Saudi Arabia. *Can. J. Infect. Dis. Med. Microbiol.* 2018; 2018: 6598918. https://doi.org/10.1155/2018/6598918
8. Bodena D., Teklemariam Z., Balakrishnan S., Tesfa T. Bacterial contamination of mobile phones of health professionals in Eastern Ethiopia: antimicrobial susceptibility and associated factors. *Trop. Med. Health.* 2019; 47: 15. https://doi.org/10.1186/s41182-019-0144-y
9. Lubwama M., Kateete D.P., Ayazika K.T., Nalwanga W., Kagambo D.B., Nsubuga M.D., et al. Microbiological contamination of mobile phones and mobile phone hygiene of final-year medical students in Uganda: A need for educational intervention. *Adv. Med. Educ. Pract.* 2021; 12: 1247. https://doi.org/10.2147/AMEP.S333223
10. Ketata N., Ben Ayed H., Ben Hmida M., Trigui M., Ben Jemaa M., Yaich S., et al. Point prevalence survey of health-care associated infections and their risk factors in the tertiary-care referral hospitals of Southern Tunisia. *Infect. Dis. Heal.* 2021; 26(4): 284–91. https://doi.org/10.1016/j.idh.2021.06.004
11. Cicciarella Modica D., Maurici M., D'alò G.L., Mozzetti C., Messina A., Distefano A., et al. Taking screenshots of the invisible: a study on bacterial contamination of mobile phones from university students of healthcare professions in Rome, Italy. *Microorganisms*. 2020; 8(7): 1075. https://doi.org/10.3390/microorganisms8071075
12. Selim H.S., Abaza A.F. Microbial contamination of mobile phones in a health care setting in Alexandria, Egypt. *GMS Hyg. Infect. Control.* 2015; 10: Doc03. https://doi.org/10.3205/dgkh000246
13. Tagoe D.N., Gyande V.K., Ansah E.O. Bacterial contamination of mobile phones: when your mobile phone could transmit more than just a call. *WebmedCentral MICROBIOLOGY*. 2011; 2(10): WMC002294. https://doi.org/10.9754/journal.wmc.2011.002294
14. Hikmah N.A., Anuar T.S. Mobile phones: a possible vehicle of bacterial transmission in a higher learning institution in Malaysia. *Malays. J. Med. Sci.* 2020; 27(2): 151–8. https://doi.org/10.21315/mjms2020.27.2.15
15. Jansson L., Akel Y., Eriksson R., Lavander M., Hedman J. Impact of swab material on microbial surface sampling. *J. Microbiol. Methods.* 2020; 176: 106006. https://doi.org/10.21315/mjms2020.27.2.15
16. Olsen M., Campos M., Lohning A., Jones P., Legget J., Bannach-Brown A., et al. Mobile phones represent a pathway for microbial transmission: A scoping review. *Travel Med. Infect. Dis.* 2020; 35: 101704. https://doi.org/10.1016/j.tmaid.2020.101704
17. Eichenberg C., Schott M., Schroiff A. Problematic smartphone use – comparison of students with and without problematic smartphone use in light of personality. *Front. Psychiatry.* 2020; 11: 599241. https://doi.org/10.3389/fpsyt.2020.599241
18. Shah P.D., Shaikh N.M., Dholaria K.V. Microorganisms isolated from mobile phones and hands of health-care workers in a tertiary care hospital of Ahmedabad, Gujarat, India. *Indian J. Public Health.* 2019; 63(2): 147–50. https://doi.org/10.4103/ijph.IJPH_179_18
19. Canales M.B., Craig G.C., Boyd Jr. J., Markovic M., Chmielewski R.A. Dissemination of pathogens by mobile phones in a single hospital. *ReconRev.* 2017; 7(3): 42–7. https://doi.org/10.15438/rr.7.3.192
20. Parthasarathy A., Wong N.H., Weiss A.N., Tian S., Ali S.E., Cavanaugh N.T., et al. SELfies and CELLfies: whole genome sequencing and annotation of five antibiotic resistant bacteria isolated from the surfaces of smartphones, an inquiry based laboratory exercise in a genomics undergraduate course at the rochester institute of technology. *J. Genomics.* 2019; 7: 26–30. https://doi.org/10.7150/jgen.31911
21. Helmi N.R.M., Zaman R.M.Q. Isolation of bacteria from mobile phones before and after decontamination: Study carried out at King Abdulaziz University, Jeddah, Saudi Arabia. *African J. Microbiol. Res.* 2017; 11(35): 1371–8. https://doi.org/10.5897/AJMR2017.8639
22. Glasset B., Herbin S., Granier S.A., Cavalie L., Lafeuille E., Guérin C., et al. Bacillus cereus, a serious cause of nosocomial infections: Epidemiologic and genetic survey. *PLoS One.* 2018; 13(5): e0194346. https://doi.org/10.1371/journal.pone.0194346
23. Noumi E., Merghni A., Alreshidi M., Del Campo R., Adnan M., Haddad O., et al. Phenotypic and genotypic characterization with MALDI-TOF-MS based identification of staphylococcus spp. isolated from mobile phones with their antibiotic susceptibility, biofilm formation, and adhesion properties. *Int. J. Environ. Res. Public Health.* 2020; 17(11): 3761. https://doi.org/10.3390/ijerph17113761
24. Ustun C., Cihangiroglu M. Health care workers' mobile phones: a potential cause of microbial cross-contamination between hospitals and community. *J. Occup. Environ. Hyg.* 2012; 9(9): 538–42. https://doi.org/10.1080/15459624.2012.697419
25. Fard R.H., Fard R.H., Moradi M., Hashemipour M.A. Evaluation of the cell phone microbial contamination in dental and engineering schools: effect of antibacterial spray. *J. Epidemiol. Glob. Health.* 2018; 8(3-4): 143–8. https://doi.org/10.2991/j.jegh.2017.10.004
26. Heyba M., Ismaiel M., Alotaibi A., Mahmoud M., Baqer H., Safar A., et al. Microbiological contamination of mobile phones of clinicians in intensive care units and neonatal care units in public hospitals in Kuwait. *BMC Infect. Dis.* 2015; 15: 434. https://doi.org/10.1186/s12879-015-1172-9

Information about the authors

Nouha Ketata, Medical doctor, Hospital Hygiene Epidemiology Department, Hedi Chaker University Hospital, University of Sfax, Tunisia, https://orcid.org/0000-0003-3806-7254 E-mail: ketatanouha@gmail.com

Yosra Mejdoub, Medical doctor, Community Health and Epidemiology Department, Hedi Chaker University Hospital, University of Sfax, Tunisia, https://orcid.org/0000-0002-8611-1486 E-mail: yosra.mejdoub85@yahoo.fr

Salma Maalej, Pharmacist doctor, Pharmacy University, University of Monastir, Tunisia, https://orcid.org/0009-0005-3978-9269 E-mail: maalejsalma91@yahoo.fr

Imen Turki, phd in health sciences, Faculty of Medicine of Sousse, Research Laboratory "Quality of Care and Management of Maternal Health Services", University of Sousse, Tunisia. https://orcid.org/0000-0003-2644-3128

Maissa Ben Jmaa, Medical doctor, Community Health and Epidemiology Department, Hedi Chaker University Hospital, University of Sfax, Tunisia, https://orcid.org/0000-0002-0129-8481 E-mail: benjmaa_maissa@medecinesfax.org

Salma Smaoui, Pharmacist doctor, Pharmacy University, University of Monastir, Tunisia, https://orcid.org/0000-0001-5323-0844 E-mail: smaoui_salma@yahoo.fr

Mouna Baklouti, Medical doctor, Community Health and Epidemiology Department, Hedi Chaker University Hospital, University of Sfax, Tunisia, https://orcid.org/0000-0003-4783-6027 E-mail: mouna.baklouti92@gmail.com

Jihen Jdidi, Medical doctor, Community Health and Epidemiology Department, Hedi Chaker University Hospital, University of Sfax, Tunisia, https://orcid.org/0000-0003-1904-8744 E-mail: jdiditrabelsijihen@gmail.com

Ferièle Messadi-Akrout, Pharmacist doctor, Pharmacy University, University of Monastir, Tunisia, https://orcid.org/0009-0009-8871-7877 E-mail: ferielemessadi@yahoo.fr

Sourour Yaich, Medical doctor, Community Health and Epidemiology Department, Hedi Chaker University Hospital, University of Sfax, Tunisia, https://orcid.org/0000-0002-2269-0837 E-mail: yaich.sourour@gmail.com

Информация об авторах

Кетата Нуха, врач, Отделение общественного здравоохранения и эпидемиологии, Университетская больница Хеди Чакер, Сфаксский университет, Сфакс, Республика Тунис. E-mail: ketatanouha@gmail.com

Меджду́б Йосра, врач, Отделение общественного здравоохранения и эпидемиологии, Университетская больница Хеди Чакер, Сфакский университет, Сфакс, Республика Тунис. E-mail: yosra.mejdoub85@yahoo.fr

Маалей Сальма, врач-фармацевт, Фармацевтический университет, Монастирский Университет, Республика Тунис. E-mail: maalejsalma91@yahoo.fr

Турки Имен, канд. мед. наук, Суский медицинский факультет, Исследовательская лаборатория "Качество охраны и организации службы охраны материнства", Суский Университет, Республика Тунис.

Бен Джмаа Маисса, врач, Отделение общественного здравоохранения и эпидемиологии, Университетская больница Хеди Чакер, Сфаксский университет, Сфакс, Республика Тунис. E-mail: benjmaa_maissa@medecinesfax.org

Смауи Сальма, врач-фармацевт, Фармацевтический университет, Монастирский Университет, Республика Тунис. E-mail: smaoui_salma@yahoo.fr

Баклути Моуна, врач, Отделение общественного здравоохранения и эпидемиологии, Университетская больница Хеди Чакер, Сфакский университет, Сфакс, Республика Тунис. E-mail: mouna.baklouti92@gmail.com

Ждиди Джихен, врач, Отделение общественного здравоохранения и эпидемиологии, Университетская больница Хеди Чакер, Сфаксский университет, Сфакс, Республика Тунис. E-mail: jdiditrabelsijihen@gmail.com

Мессади-Акрут Фериэль, врач-фармацевт, Фармацевтический университет, Монастирский Университет, Республика Тунис. E-mail: ferielemessadi@yahoo.fr

Яич Сурур, врач, отделение общественного здравоохранения и эпидемиологии, университетская больница Хеди Чакер, Сфакский университет, Республика Тунис. E-mail: yaich.sourour@gmail.com