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Impact of Occupational Exposure on Bacterial Community Dynamics in Selected Niches of Human Dermal Ecosystem

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ABSTRACT
The impact of occupational exposure on bacterial community dynamics in selected ecological niches of the human dermal ecosystem was examined. Samples were collected from three skin niches (palms, forearms and feet) of volunteers for different occupations (automobile mechanics, civil servants, food vendors, traffic officers, masons and welders) to make a composite and examined using standard microbiological methods. Results showed that 46.7% of the bacteria abundance was from the palms, 28.7% from feet and 24.6% from forearms. Based on occupation type, the highest bacterial abundance was isolated from Mason (23.5%) while the lowest was recorded in Civil servants (11.4%). Based on occupational exposure by niches, palms have the highest bacterial abundance from Masons (26.8%) while the lowest was from Auto-mechanics (9.4%). Forearms have the highest from Masons (20.9%) while the lowest was from civil servants (6.0%). Feet have the highest from Masons (20.5%) while the lowest was from Civil servants (10.3%). Eight (08) bacterial species (*Micrococcus luteus, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Streptococcus viridans, Citrobacter* spp., *Escherichia coli* and *Proteus mirabilis*) were isolated from the palms, Five (05) (*Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Staphylococcus saprophyticus* and *Pseudomonas aeruginosa)* from the fore arms while Seven (07) species (*Corynebacterium* spp., *Propiniobacterium granulosum, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Proteus mirabilis* and *Pseudomonas aeruginosa)* from the feet. *B. subtilis, S. aureus, S. epidermidis* were common to all niches. Occupational exposure can cause dermal bacterial community dynamics which could be of potential dermatological importance.

Keywords: Bacteria; Ecology; Body Parts; Occupation

INTRODUCTION
Diverse microbial populations inhabit different ecological niches on human skin and are impacted by environmental conditions such as humidity, temperature, pH, lipid content, and the presence of host-produced antimicrobials (Bouffard *et al.*, 2009). Some of the bacteria defend the skin against the invasion of pathogens by signaling immune system cells and inducing an immunological response. Other bacteria operate as a protective agent against pathogenic bacteria by secreting chemicals that inhibit harmful microbes from invasion (Leena *et al.*, 2016).

Ecological niches of the skin ecosystem such as the sebaceous or oily area zone (head, neck, and trunk), moist zone (elbow creases, spaces between toes), and dry areas (wide surfaces of the arms and legs) are the three dermal habitats (environments) that skin bacteria prefer to inhabit (Zipperer *et al.*, 2016). Sebaceous zones ecologically have a higher species richness than moist and dry ones. The spaces between fingers and toes, the axillae, and the stump of the umbilical cord were the parts of the body where humans differed the least from one another in terms of bacterial species (Grice *et al.*, 2009).

The human dermal ecosystem is built up of microbial communities that live in symbiotic relationships with the host organism and are constantly communicating via complex signals produced by the innate and adaptive immune systems (Van Rensburg *et al.*, 2015). The ecosystem is typically predominated by the phylum Actinobacteria, Proteobacteria, Firmicutes, and Bacteroidetes while the most prevalent genera within these phyla are those in *Propionibacterium, Corynebacterium, Staphylococcus, Micrococcus,* and *Brevibacterium* (Van Rensburg *et al.*, 2015; Mukherjee *et al.*, 2016). The skin natural bacterial population are influenced by delivery methods. For example, *Acinetobacter* and *Staphylococcus* are more prevalent on the skin ecosystem of babies delivered via Caesarean section while *Lactobacillus* and *Prevotella* are on those conventionally delivered via the vagina (Dominguez-Bello *et al.,* 2010).

Dermal bacterial abundance and diversity change over time as a result of endogenous and exogenous variables including age, gender, cosmetic use, biogeography and genetics that each individual possesses (Capone *et al.,* 2011; San Miguel and Grice, 2015; Alisa *et al.*, 2017) that may have an impact on this balanced system, allowing them to collaborate with their hosts to either sustain or disturb the local dermal ecology (Sanford and Gallo, 2013). Dermal bacteria can cause minor infections (such as abscesses, boils and cellulitis) to life-threatening conditions including meningitis, food poisoning, and development of inflammatory dermal problems such as infections, allergies, or autoimmune illnesses (Nakatsuji *et al.*, 2017).

Researchers have been interested in the normal bacterial flora of the human skin for a long time, but it is challenging to find an accurate description of the typical bacterial population of ordinary human skin (Mukherjee *et al.,* 2016). Understanding the delicate balance between the host ecosystem, and bacterial population can improve the skin as an ecosystem made up of living biological and physical components that inhabit various habitats. This study therefore examines the impact of occupational exposure on the abundance and distribution of bacterial communities in selected ecological niches of the human dermal ecosystem.

MATERIALS AND METHODS

Study Area

This investigation was conducted in Abeokuta, the capital of Ogun State in Southwest Nigeria (7^o 9' 39''N, 3^o 20' 54''E), which is located on the east bank of the Ogun River, close to a cluster of rocky outcrops in wooded savanna, 77 km (48 miles) by railway, or 130 km (81 miles) by water North of Lagos. 449,088 people are living in Abeokuta and the surrounding area as of 2006. It is located in Nigeria's rainforest zone and has a tropical climate with distinct wet and dry seasons; with a dry season lasting roughly 130 days. Ten (10) participants from six (6) different occupations were taken into consideration for the research's purposes which was carried out in June 2023. This comprises traffic officers, civil servants, food vendors, masons, welders and automobile mechanics (Table 1).

Participant Consent

Before the collection of the dermal samples, the purpose of the study was discussed verbally and acceptance was obtained from the participants.

Sampling Procedure

The ecological niches (Palms, Fore Arms and Feet) of the ten participants were sampled from both the right and left sides of the body to make a composite for each occupation. The collection was done by delineation a $16cm^2$ area of the parts with a sterile swap and scrubbing the skin in such area with swabs moistened in normal saline. These swabs were suspended in 2.5 cm^3 of freshly prepared normal saline solution in test tubes and shaken on a wrist-action shaker for 5 minutes (Ogai *et al.,* 2018). Each sample was cultured in triplicates.

Quality Control and Bacterial Examination

All glass wares and kits used were sterilized using autoclaving and aseptic methods. The workbench and the used areas were sterilized with freshly prepared 90% ethanol solution. A spirit lamp was lit up to ensure that the air in the vicinity of the workbench was free of contaminants. The nutritive medium used was Nutrient agar for bacteria isolation (Umoren, 2021). One (1) mL of the swab solution was transferred in 9mL distilled water. This was then followed by serial dilution into 9mL of distilled water into different dilution factors of 10^{-1}, 10^{-2} and 10^{-3}. 1 mL of each of these dilutions was subsequently inoculated into sterile plates after which the sterilized prepared media were poured into the plates. Bacteria plates were incubated at 37^oC for 18 to 48 hours. The bacterial abundance (count) was determined by visual counting (Ademolu and Idowu, 2011). The distinct colonies were sub cultured into other selective mediums to get a pure culture. The identification of the bacteria colonies was done using classification schemes of Bergey's Manual of Systematic Bacteriology (Cheesbrough, 2006) and according to Ademolu and Idowu (2011).

Characterization and Identification of the bacterial isolates

The bacterial isolates were characterized using the following features (size, form or shape, edge, texture, degree of opacity and colour) of each colony (Cheesbrough, 2006). They were also characterized based on their shapes and appearance using differential Gram's staining technique (Cheesbrough, 2006; Umoren, 2021). The biochemical tests done on the isolates included catalase, coagulase, urease, indole, citrate, hydrogen sulphide, methyl red, oxidase, voges-proskauer, and carbohydrate fermentation test (Cheesbrough, 2006).

Data Management and Analysis

Data collected was subjected to statistical analyses using the Statistical Package for Social Sciences (SPSS) Version 21.0. Value was expressed as in Mean ±SD. Microsoft Excel was used to compute the percentage and generate data visualization.

Table 1: Description of the occupations of people used for this study

Occupation	Description
Auto-Mechanics	A mechanic who services and fixes automobiles is known as an auto mechanic, automotive technician or motor mechanic; they may occasionally specialize in one or more car brands or work with any brand. Their primary responsibility when fixing cars is to precisely identify the issue and carry out a speedy repair. Their work may involve replacing one or more parts as assemblies or repairing a single part (Auto mechanic, 2024).
Civil servants	The word "civil service" refers to a sector of government made up mostly of career civil servants who are hired based on their professional ability rather than being appointed or elected, and whose institutional tenure often endures changes in political power. A person engaged in the public sector by a government department or agency for public sector endeavours is referred to as a civil servant, sometimes known as a public servant (Longley, 2023).
Food vendors	A food vendor prepares and provides the general public with ready-to-eat cuisine. At sporting or event venues, fairs, and festivals, food vending frequently takes place at food concessions. Some vendors have a mobile kitchen that serves cuisine at various locations (Reznar *et al.*, 2019).
Masons	Mason also known as a bricklayer is a worker whose profession involves constructing units made of different synthetic or natural mineral goods, such as tiles, bricks, or cinder blocks, typically with the aid of mortar or concrete as a binding material (Masonry, 2024).
Traffic officers	Officers who control traffic or work in a traffic policing unit to enforce traffic laws are known as traffic officers, often known as traffic cops or traffic enforcers. Officers who deal with traffic violations on other roads as well as policemen who patrol main thoroughfares make up the traffic police (Traffic officer, 2024).
Welders	Anyone who uses welding equipment, whether they are professionals or amateurs, is a welder, possibly especially if they do it frequently. A welder is a tradesperson who focuses on joining materials (such as steel, aluminium, brass, stainless steel, etc.) together. The machine is referred to as the welding power supply, while the operator is referred to as the welder (Welder, 2023).

RESULTS

Bacterial Ecological Abundance

The mean ecological abundance of bacteria from the selected ecological niches on human skin is presented in Table 2. Generally, the result revealed a total of two hundred and seventy-two (272) bacteria abundance from the studied ecological dermal niches. One hundred and twenty-seven (46.7%) of the total bacterial abundance was from the palms niche, seventy-eight (28.7%) of the total bacterial abundance was from the feet niche while sixty-seven (24.6%) of the total bacterial abundance was from the forearms niche. According to the total occupational exposure, Mason (64) accounted for 23.5% of the total bacterial abundance followed by Traffic officers (49) accounting for 18.0% of the total bacterial abundance while the lowest bacterial abundance was recorded in Civil servants (31) accounting for 11.4% of the total bacterial abundance.

The bacteria abundance by occupation appears in the order of Masons> Traffic officers> Food vendors> Welder> Auto-mechanics> Civil servant.

Based on occupational exposure by niches, the palms' ecological niche has the highest bacterial abundance from Masons (26.8%) followed by Traffic officers (18.1%) while the lowest from Auto-mechanics (9.5%). The bacteria abundance by occupation appears in the order of Masons>Traffic officers>Food vendors>Civil servant>Welder>Auto-mechanics. The Forearms niches have the highest bacterial abundance from Masons (20.9%) followed by both Food vendors and Auto-mechanics (19.4%) respectively while the lowest was from civil servants (6.0%). The bacteria abundance appears in the order of Masons> Food vendors= Auto-mechanics> Welders> Traffic Officers> Civil Servants. The Feet ecological niches have the highest mean bacterial abundance from Masons (20.5%) followed by both Traffic Officers and Auto-mechanics (19.2%) respectively while the lowest was from Civil servants (10.3%). The bacteria abundance appears in the order of Masons> Traffic Officers= Auto-mechanics> Welders> Food vendors> Civil Servants.

Bacterial Ecological distribution on parts of the Human skin

The distribution of bacterial species on the selected dermal niches is presented in Tables 3-5. The results showed that the palm has the highest bacterial species followed by the feet while the least was in the forearm. Eight (08) bacterial species (*Micrococcus luteus, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Streptococcus viridans, Citrobacter spp., Escherichia coli* and *Proteus mirabilis*) were isolated from the palm niche; 50% of the bacterial species were observed in the palm of Civil Servants, Food Vendors, Traffic Officers and Welders. *Staphylococcus aureus* and *Staphylococcus epidermidis* were distributed across all occupation type (Table 3).

Five (05) bacterial species (*Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Staphylococcus saprophyticus* and *Pseudomonas aeruginosa)* were isolated from the fore arm niche. Sixty percent (60%) of the bacterial species was present in the fore arms of all occupation while *Bacillus subtilis* was the only bacterial species distributed across all the fore arm niche. *Staphylococcus aureus* and *Staphylococcus epidermidis* was distributed across the occupation type except for Auto-Mechanics and Food Vendors respectively (Table 4).

Table 2: Mean Bacterial Ecological Abundance on selected parts of Human skin

Occupation	Ecological Niche (cfu $\times10^2$)						Total	Percentage (%)
	Palms	Percentage (%)	Fore Arms	Percentage (%)	Feet	Percentage (%)		
Auto-Mechanics	12 ±0.12	9.4	13 ±0.25	19.4	15±0.12	19.2	40	14.7
Civil servants	19 ±0.00	15.0	04±0.12	6.00	08±0.12	10.3	31	11.4
Food vendors	22±1.41	17.3	13±0.50	19.4	11±0.00	14.1	46	16.9
Masons	34±0.71	26.8	14±2.12	20.9	16± 0.00	20.5	64	23.5
Traffic officers	23±0.50	18.1	11±0.12	16.4	15±0.25	19.2	49	18.0
Welders	17±2.12	13.4	12±0.00	17.9	13±0.50	16.7	42	15.4
Total	127 (46.7)	100	67 (24.6)	100	78 (28.7)	100	272	100

Table 3: Ecological Distribution of Bacteria on Palms Ecological Niches

Taxonomic taxa					Occupation					
Phylum	Class	Order	Family	Scientific name	Auto-mechanics	Civil servants	Food vendors	Masons	Traffic officers	Welders
Actinomycetota	Actinomycetia	Micrococcales	Micrococcaceae	*Micrococcus luteus*			*			
Bacillota	Bacilli	Bacillales	Bacillaceae	*Bacillus subtilis*		*			*	*
			Staphylococcaceae	*Staphylococcus aureus*	*	*	*	*	*	*
				Staphylococcus epidermidis	*	*	*	*	*	*
		Lactobacillales		*Streptococcus viridans*	*				*	
Pseudomonadota	Gammaproteo Bacteria	Enterobacterales	Enterobacteriaceae	*Citrobacter spp.*			*			
				Escherichia coli		*		*		
				Proteus mirabilis						*

Key: * = Present

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Table 4: Ecological Distribution of Bacteria Population on Fore Arms Ecological Niches

Taxonomic taxa					Occupation					
Phylum	Class	Order	Family	Scientific Name	Auto-mechanics	Civil servants	Food vendors	Masons	Traffic Officers	Welders
Actinomycetota	Actinomycetia	Mycobacteriales	*Corynebacteriaceae*	*Corynebacterium* spp.			*			*
				Propiniobacterium granulosum					*	
Bacillota	Bacilli	Bacillales	Bacillaceae	*Bacillus subtilis*				*		
			Staphylococcaceae	*Staphylococcus aureus*	*	*	*	*	*	*
				Staphylococcus epidermidis		*	*		*	*
Pseudomonadota	Gammaproteo Bacteria	Enterobacterales	Enterobacteriaceae	*Proteus mirabilis*	*					
		Pseudomonadales	*Pseudomonadaceae*	*Pseudomonas aeruginosa*	*					

Table 5: Ecological Distribution of Bacteria population on Feet Ecological Niches

Taxonomic taxa					Occupation					
Phylum	Class	Order	Family	Scientific name	Auto-mechanics	Civil servants	Food vendors	Masons	Traffic officers	Welders
Bacillota	Bacilli	Bacillales	Bacillaceae	*Bacillus subtilis*	*	*	*	*	*	*
			Staphylococcaceae	*Staphylococcus aureus*		*	*	*	*	*
				Staphylococcus epidermidis	*	*		*	*	
				Staphylococcus saprophyticus			*			*
Pseudomonadota	Gammaproteo Bacteria	*Pseudomonadales*	*Pseudomonadaceae*	*Pseudomonas aeruginosa*	*					

Key: * = Present

Seven (07) bacterial species (*Corynebacterium* spp., *Propiniobacterium granulosum, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Proteus mirabilis* and *Pseudomonas aeruginosa)* were isolated from the feet niche. Forty-three (43%) of the bacterial species were present in the feet of Auto-mechanics, Food vendors, Traffic officers and Welders. *Staphylococcus aureus* was distributed across the feet niches while *Staphylococcus epidermidis* was also distributed across the feet except for Auto-Mechanics and Masons (Table 5).

DISCUSSION

Occupational exposure plays a role in shaping the bacterial community in the human dermal ecosystem (Nazaroff, 2019) and understanding the dynamics of different skin niches is valuable for dermatological research (Hannigan and Grice 2013). The obvious high bacterial abundance in Masons across dermal niches, palms and feet of traffic officers, the forearms and feet of Auto mechanics and the forearms of the food vendors is traceable to the nature of their work environments and the types of substances exposed. Manson and Auto mechanics are well known to be linked with the contaminated soil, water and dust particulates from their work activities (Wu and Li, 2015; Nazaroff, 2019). Furthermore, Traffic officers and food vendors might have been exposed to these bacteria through exposure to contaminated outdoor dust or hand-to-surface/ hand contact. Soil, dust and water have been reported to harbour a wide of bacterial species such as *P. aeruginosa*, *M. luteus* and *P. miribalis* (Wu and Li, 2015; Jamil *et al*., 2023). The obvious high bacterial abundance in palms can be linked to frequent exposure to environmental surfaces, objects and handshaking (Edmonds-Wilson, 2015). The low bacterial diversity from on the feet is in line with the work of (Findley *et al*., 2013) who reported a lower bacterial diversity in the feet than in the arm and core body. *Staphylococcus aureus, S. epidermidis* and *B. subtilis* were the bacterial species common to all dermal niches. These bacteria including *M. luteus* are widely known to be skin-natural flora (Van Rensburg *et al.*, 2015; Cundell, 2018), Although, bacterial diversity of the skin can change over time as a result of environmental exposure (San Miguel and Grice, 2015) and may have an impact on the balanced system, leading to opportunistic health conditions (Findley *et al*., 2013). *Pseudomonas aeruginosa* is common to forearms and feet while *P. mirabilis* is common to the palm and feet. *Pseudomonas aeruginosa is an* ubiquitous environmental bacterium which causes opportunistic human infections (Wu *et al*., 2014). *Micrococcus luteus, Streptococcus viridans, Citrobacter* spp. and *E. coli.* are unique to the palms. *E. coli* is emerging as one of the most important human pathogens globally (Poolman *et al*., 2022). However, in this case, it could be a potential non-intestinal infection, categorized as extra-intestinal pathogenic *E. coli* (Ranjan *et al*., 2017). *Staphylococcus saprophyticus* is unique to the feet while *Corynebacterium spp.* and *P. granulosum* are unique to the feet. This is consistent with a study by (Findley *et al*., 2013; Byrd *et al*., 2018) who reported predominantly *Propionibacterium, Corynebacterium spp. and Staphylococcus* from the toe region. The differences in bacterial abundances and distribution among occupational groups give an insight that type of occupation can act as a catalyst for exposure risk to opportunistic potentially pathogenic bacteria to establish disease (Montano, 2014).

CONCLUSION

This research provides insight into the impact of occupational exposure on bacterial community dynamics within the selected niches of the human dermal ecosystem.

The variations observed in bacterial abundance and distribution among occupational groups and skin niches underscore the need for further investigation into occupational health and safety. However, Mason, traffic and Auto mechanics are at a higher risk of occupational hazards. Sensitization and other appropriate measure must be done to minimize exposure and reduce the risk of health problems.

REFERENCES

Ademolu, K. O. and Idowu, A. B. (2011). Occurrence and distribution of microflora in the gut regions of the variegated grasshopper *Zonocerus variegatus* (Orthoptera: Pyrgomorphidae) during development. *Zoological Studies*, *50*(4), 409-415.

Alisa, O., Fredricks, D. N. and Tagami, H. (2017) Microbial ecology of human skin in health and disease. *Int. J. Cosmet Sci*. 4: 13–15.

Auto mechanic (2024). In *Wikipedia*. https://en.wikipedia.org/wiki/Auto_mechanic (Accessed January 5, 2024)

Bouffard, G. G., Blakesley, R. W., Murray, P. R., Green, E. D., Turner, M. L., Segre, J. A. (2009). Topographical and temporal diversity of the human skin microbiome. Science 324:1190_1192 DOI 10.1126/science.1171700.

Byrd, A. L., Belkaid, Y. and Segre, J. A. (2018). The human skin microbiome. *Nature Reviews Microbiology*, *16*(3), 143-155. https://doi.org/10.1038/nrmicro.2017.157

Capone, K. A, Dowd, S. E, Stamatas, G. N. and Nikolovski, J. (2011). Diversity of the human skin microbiome early in life. *Journal of Investigative Dermatology* 131:2026_2032 DOI 10.1038/jid.2011.168.

Cheesbrough, M. (2006) *District Laboratory Practice in Tropical Countries*, second edition Part 2, Cambridge University Press, The Edinburgh Building, Cambridge CB2 8RU, UK (Accessed November 2023)

Cundell, A.M., (2018). Microbial ecology of the human skin. *Microbial ecology*, 76(1), pp.113-120.

Dominguez-Bello, M. G., Costello, E. K., Contreras, M., Magris, M., Hidalgo, G., Fierer, N., & Knight, R. (2010). Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns. *Proceedings of the National Academy of Sciences*, *107*(26), 11971-11975.

Edmonds-Wilson, S.L., Nurinova, N.I., Zapka, C.A., Fierer, N. and Wilson, M., 2015. Review of human hand microbiome research. *Journal of dermatological science*, 80(1), pp.3-12.

Findley, K., Oh, J., Yang, J., Conlan, S., Deming, C., Meyer, J. A. and Segre, J. A. (2013). Topographic diversity of fungal and bacterial communities in human skin. *Nature*, *498*(7454), 367-370

Grice, E. A., Kong, H. and Conlan, S. (2009): Topographical and Temporal Diversity of the Human Skin Microbiome, 2nd Edition. Scientific Publishers, India Page 55.

Hannigan, G.D. and Grice, E.A., 2013. Microbial ecology of the skin in the era of metagenomics and molecular microbiology. Cold Spring Harbor perspectives in medicine, 3(12).

Jamil, R.T, Foris, L.A, Snowden, J. (2023) Proteus mirabilis Infections. [Updated 2023 Jun 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK442017/

Leena, C., Chanisada, W., Papapit, T., Waranaree, W., Adhiratha, B., Kanokvalai, K. and Visanu, T. (2016) Prevalence of Cutaneous Bacterial Colonization in Thai Patients with Psoriasis *J Med Assoc Thai* 2016; 99 (4): 418-23

Longley, R. (2023) "*What Is Civil Service? Definition and Examples." ThoughtCo,* Accessed Jan. 9, 2023, thoughtco.com/what-is-civil-service-definition-and-examples-7069012.

Masonry (2024). In *Wikipedia*. https://en.wikipedia.org/wiki/Masonry (Accessed January 1, 2024)

Montano, D. (2014). Chemical and biological work-related risks across occupations in Europe: a review. *Journal of Occupational Medicine and Toxicology*, 9(1), pp.1-13.

Mukherjee, S., Mitra, R., Maitra, A., Gupta, S., Kumaran, S., Chakrabortty, A. and Majumder P. P. (2016). Sebum and hydration levels in specific regions of the human face significantly predict the nature and diversity of facial skin microbiome. *Scientific Reports* 6:36062 DOI 10.1038/srep36062

Nakatsuji, T., Chen, T. H., Narala, S., Chun, K. A., Two, A. M., Yun, T., Shafiq, F., Kotol, P. F., Bouslimani, A., Melnik, A. V., Latif, H., Kim, J. N., Lockhart, A., Artis, K., David, G., Taylor, P., Streib, J., Dorrestein, P. C., Grier, A., Gill, S. R., Zengler, K., Hata, T. R., Leung, D. Y., Gallo, R. L. (2017). Antimicrobials from human skin commensal bacteria protect against Staphylococcus aureus and are deficient in atopic dermatitis. *Sci. Transl. Med. 9*, eaah4680

Nazaroff, W.W., 2019. Embracing microbes in exposure science. *Journal of exposure science & environmental epidemiology*, 29(1), pp.1-10.

Ogai, K., Nagase, S., Mukai, K., Iuchi, T., Mori, Y., Matsue, M., Sugitani, K., Sugama, J., & Okamoto, S. (2018). A Comparison of Techniques for Collecting Skin Microbiome Samples: Swabbing Versus Tape-Stripping. *Frontiers in Microbiology*, *9*, 407820. https://doi.org/10.3389/fmicb.2018.02362

Poolman, J. T., Geurtsen, J., & Weerdenburg, E. (2022). *Escherichia coli*. *Reference Module in Biomedical Sciences*. https://doi.org/10.1016/B978-0-323-99967-0.00050-8

Ranjan, A., Shaik, S., Nandanwar, N., Hussain, A., Tiwari, S. K., Semmler, T. and Ahmed, N. (2017). Comparative genomics of Escherichia coli isolated from skin and soft tissue and other extraintestinal infections. *MBio*, *8*(4), 10-1128.

Reznar, M.M., Brennecke, K., Eathorne, J. *et al.* (2019). A cross-sectional description of mobile food vendors and the foods they serve: potential partners in delivering healthier food-away-from-home choices. *BMC Public Health* **19**, 744 (2019). https://doi.org/10.1186/s12889-019-7075-8

San Miguel, A. and Grice, E. A. (2015). Interactions between host factors and the skin microbiome. Cellular and Molecular Life Science 72:1499_1515 DOI 10.1007/s00018-014-1812-z.

Sanford, J. A. and Gallo, R. L. (2013). Functions of the skin microbiota in health and disease. *Semin. Immunol*. 25, 370–377

Traffic officer (2024). In *Wikipedia*. https://en.wikipedia.org/wiki/Traffic_police (Accessed January 6, 2024).

Umoren, O. D. (2021). Wild Sage (*Lantana camara)* Flower and Leave: Bactericidal Efficacy on Bacterial Growth. *International Journal of Multidisciplinary Research and Explorer (IJMRE). 1*(4): Pp. 33–36. http://doi-ds.org/doilink/03.2021-21581474/IJMRE

Van Rensburg, J. J, Lin, H., Gao, X., Toh, E., Fortney, K. R, Ellinger, S., Zwickl, B., Janowicz, D. M., Katz, B. P., Nelson, D. E., Dong, Q. and Spinola, S. M. (2015). The human skin microbiome associates with the outcome of and is influenced by bacterial infection. *MBio* 6: e01315_15 DOI 10.1128/mBio.01315-15.

Welder (2023). In *Wikipedia*. https://en.wikipedia.org/wiki/Welder (Accessed November 16, 2023).

Wu, M., & Li, X. (2015). *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. In *Molecular medical microbiology* (pp. 1547-1564). Academic Press.

Wu, W., Jin, Y., Bai, F., and Jin, S. (2014). *Pseudomonas aeruginosa*. *Molecular Medical Microbiology (Second Edition)*, 753-767. https://doi.org/10.1016/B978-0-12-397169-2.00041-X

Zipperer, M. C., Konnerth, C., Laux, A., Berscheid, D., Janek, C., Weidenmaier, M., Burian, N. A., Schilling, C., Slavetinsky, M., Marschal, M., Willmann, H., Kalbacher, B., Schittek, H., Brötz-Oesterhelt, S., Grond, A., Peschel, B. and Krismer, A. (2016). Human commensals producing a novel antibiotic impair pathogen colonization. *Nature* 535, 511–516.