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Assessment of bacterial contamination rate in the public transportation system and bacterial diseases threat

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Abstract

When we use public transportation to get to our destination we might not think about germs and bacteria which threaten our health in these vehicles. In this article, our purpose is to assess the contamination rate in each part of public transportation and compare these rates with each other. Briefly, we have mentioned in what way and by which pathogen can bacteria be dangerous for passengers of these vehicles. it is crucial to assess these factors in order to prevent epidemics, diseases, and problems that are involved with bacteria spreading in public vehicles. Bacteria species that are assessed are; Staphylococcus, Streptococcus, Enterococcus, E.coli, Klebsiella, Enterobacter, Acinetobacter, Haemophilus, Shigella, and Bacillus subtilis. Vehicles that are used to assess these bacterial contaminations contain non-taxi transporter cars, cabs, private cabs, buses, and vansthese bacteria were chosen after primary identifications by comparing the rates among all existing bacteria.all standards were noted by the time of sampling in order to have an accurate study and result . by getting informed about the contamination rate in different public transportations people who are in danger (like immune-suppressed people) could use safer systems depend on their situation . also , this study can help town executive directors in order to make a safer public transportation system in order to improve health among people who use this system daily.

Keywords: *bacterial contaminations, public transportation system, public transportations,bacterial diseases epidemies, bacterial disease transmissions , airborne bacteria, bacterial pollutant public vehicles*

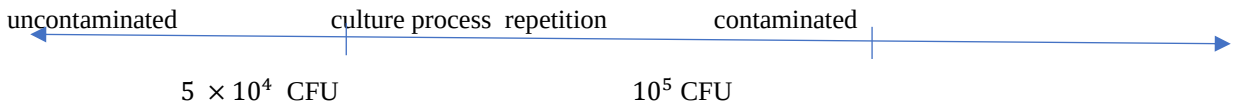
Introduction

This article assesses the level of contamination of different surfaces of 6 species of vehicles to 10 species of bacteria. This consideration helps us identify groups sensitive to different species of bacteria and give them usage instructions. Also, in the various possible epidemics, we can investigate the role of vehicles in this epidemy and prevent their occurrence. Bacterial contamination was measured using bacterial culture, which will be explained in the research methods. by getting informed about the contamination rate in different public transportations people who are in danger (like immune-suppressed people) could use safer systems depend on their situation . also , this study can help town executive directors in order to make a safer public transportation system in order to improve health among people who use this system daily

Research method :

This research was done in Tehran, Iran for a period of 4 months, from October 1st, 2021 to January 30th, 2022 in autumn and winter. all permissions were given by the drivers and passengers during the whole sampling. for the sampling from the specified parts of vehicles, we used sterilized swabs in sterilized test tubes containing 2cc distilled water. For sampling, we scrolled swabs on the marked surfaces. after that, we passaged swabs in transport media containing nutrient agar. These transport media were taken to the laboratory as soon as possible. in the laboratory, we cultured these samples in 6 distinguished plates containing: blood agar, nutrient agar, EMB, chocolate agar, McConkey agar, and SS agar for a period of 24 to 48 hours, at a temperature of 37 degrees centigrade in the incubator. After the culture process, we assessed these plates by the bacteriologic test like; catalase test, oxidase test, gram-staining test, etc. After primary considerations, we specified the bacteria species and counted them by colony count on the scale of CFU. The contamination standard in this research was 10^5 CFU, which means if a bacteria colony passes this number, its plate is contaminated by this bacteria. *it is necessary to say that each plate is intended to be contaminated by only the greatest group of bacteria species by number*.

If the colony number was more than 10^5 , the plate was intended to be contaminated after the primary culture. if the colony number was fewer than 5×10^4 , the plate was intended to be clean. if the contamination rate was between these numbers we did all the culture processes once again in order to decrease the accuracy as much as possible.



Results :

The results obtained from the various surfaces of each species of the vehicle are given in 9 tables The columns show bacteria species and rows show different parts of vehicles. The mentioned numbers indicate the contamination obtained after performing the bacteria culture, in the way previously mentioned in the research methods section. Next to the numbers in the columns is a percentage that indicates the fraction of total surface pollution relevant to the vehicle's part. The last row shows a fraction of the pollution relevant to a particular vehicle. We checked the same surfaces on all vehicles unless the vehicle lacked the surface. For example, the car does not have the same inner parts as the bus does. In addition, in sections such as Tables 6 and 7, we could not perform sampling like other sections due to lack of permission, and the studies were more limited in these two vehicles. In the following, we will examine each table.

Table 1: vehicle numbers

	number	**percent**
n.t.t car	512	40.89%

cabs	357	28.51%
p.cab	193	15.42%
bus	103	8.23%
van	87	6.95%
total	1252	100%

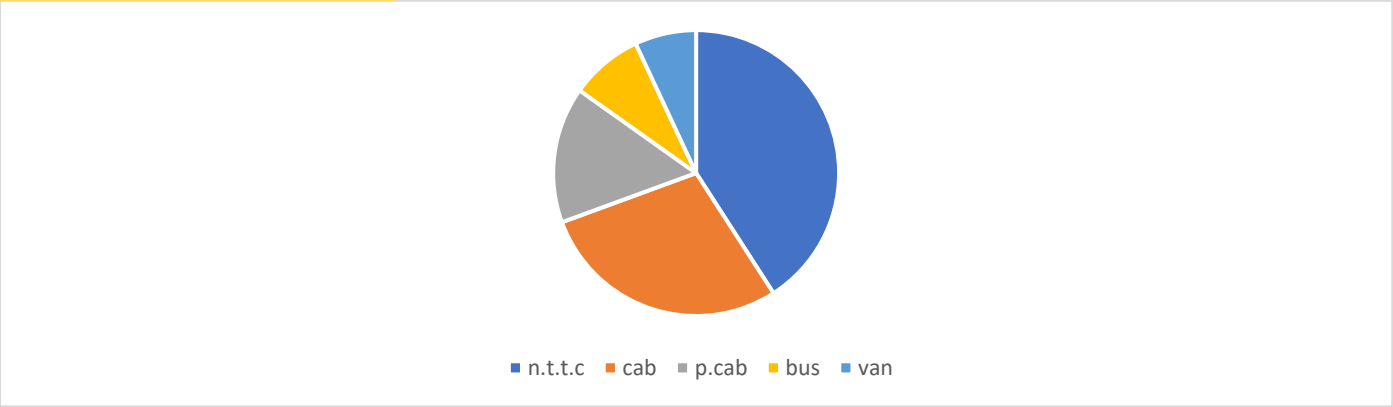


Fig.1 : **: vehicle numbers**

Table1 and fig.1 show us the number of vehicles tested

Table 2: vehicle parts

	car	cab	p.cab	bus	van	total
ext. door handles	**1145**	**707**	**323**	**_**	**_**	**2075**
steering wheel	**421**	**186**	**141**	**46**	**12**	**806**
gear shifter	**412**	**322**	**142**	**_**	**_**	**874**
int. mirror	**402**	**320**	**140**	**_**	**_**	**862**

wing mirrors lever	**821**	**311**	**182**	**_**	**_**	**1314**
starter switch	**383**	**213**	**101**	**_**	**_**	**697**
a/c vents	**417**	**157**	**87**	**_**	**_**	**661**
Internal door handles	**1045**	**357**	**185**	**_**	**29**	**1616**
window glass lifter lever	**1011**	**350**	**183**	**_**	**_**	**1544**
int. door handles	**1035**	**257**	**121**	**_**	**_**	**1413**
seats	**1027**	**596**	**174**	**103**	**87**	**1987**
Bus passenger handles	**_**	**_**	**_**	**103**	**_**	**103**
total	**8119**	**3776**	**1679**	**252**	**128**	**13954**

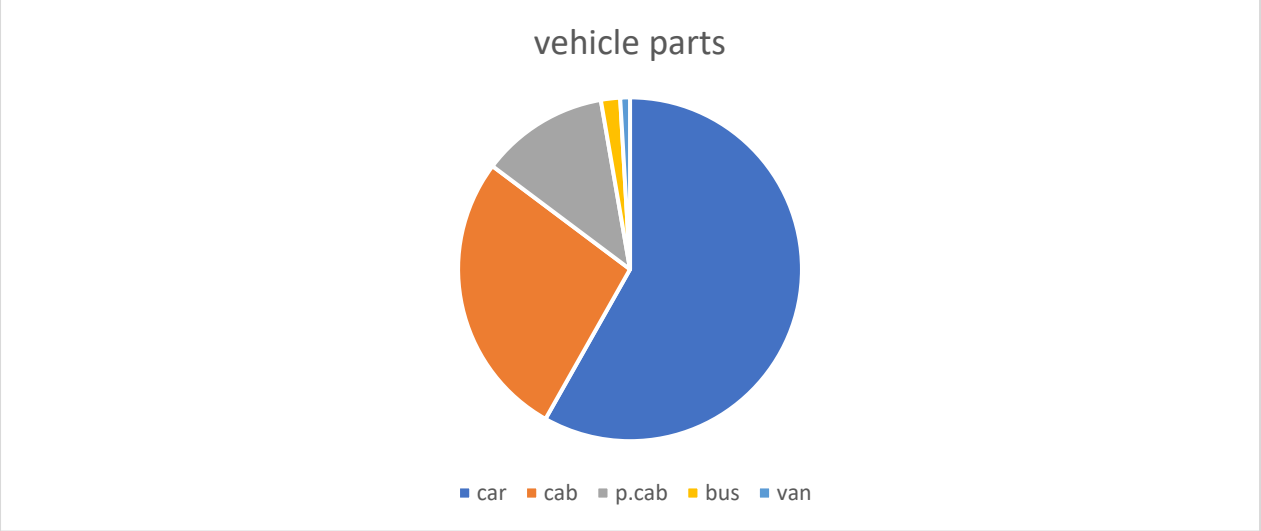


Fig.2 : vehicle parts

table 2 and fig2 show the multiplicity of each of the different parts which are examined in different vehicles.

Table 3 : non-taxi transporter cars

	Staphylococcus	Streptococcus	Enterococcus	E.Coli	klebsiella	Entrobacter	Acintobacter	Haemophilus	shigella	bacillus subtilis	total
ext. door handles	471	53	41	343	35	68	49	29	5	51	1145
	5.827	0.656	0.507	4.243	0.433	0.841	0.606	0.359	0.062	0.631	14.166
steering wheel	192	17	23	78	9	23	29	17	3	29	420
	2.375	0.210	0.285	0.965	0.111	0.285	0.359	0.210	0.037	0.359	5.196
gear shifter	191	15	21	72	8	28	38	11	2	25	411
	2.363	0.186	0.260	0.891	0.099	0.346	0.470	0.136	0.025	0.309	5.085
int. mirror	183	25	20	75	5	27	33	12	1	21	402
	2.264	0.309	0.247	0.928	0.062	0.334	0.408	0.148	0.012	0.260	4.973
wing mirrors lever	297	48	49	255	7	53	61	16	_	35	821
	3.674	0.594	0.606	3.155	0.087	0.656	0.755	0.198		0.433	10.157
starter switch	181	19	20	81	6	27	25	3	_	21	383
	2.239	0.235	0.247	1.002	0.074	0.334	0.309	0.037		0.260	4.738
a.c vents	148	28	18	76	_	33	36	2	_	42	383
	1.831	0.346	0.223	0.940		0.408	0.445	0.025		0.520	4.738
int . Door handle	435	37	46	303	21	62	71	12	_	58	1045
	5.382	0.458	0.569	3.749	0.260	0.767	0.878	0.148		0.718	12.928
window glass lifter lever	368	30	52	316	8	63	92	3	_	79	1011
	4.553	0.371	0.643	3.909	0.099	0.779	1.138	0.037		0.977	12.508
int. door lever	451	41	45	261	5	67	85	2	_	78	1035
	5.580	0.507	0.557	3.229	0.062	0.829	1.052	0.025		0.965	12.805
seats	471	40	41	270	3	81	63	3	_	55	1027
	5.827	0.495	0.507	3.340	0.037	1.002	0.779	0.037		0.680	12.706
bus passenger handles	_	_	_	_	_	_	_	_	_	_	_
total	3388	353	376	2130	107	532	582	110	11	494	8083
	41.915	4.367	4.652	26.352	1.324	6.582	7.200	1.361	0.136	6.112	100.000

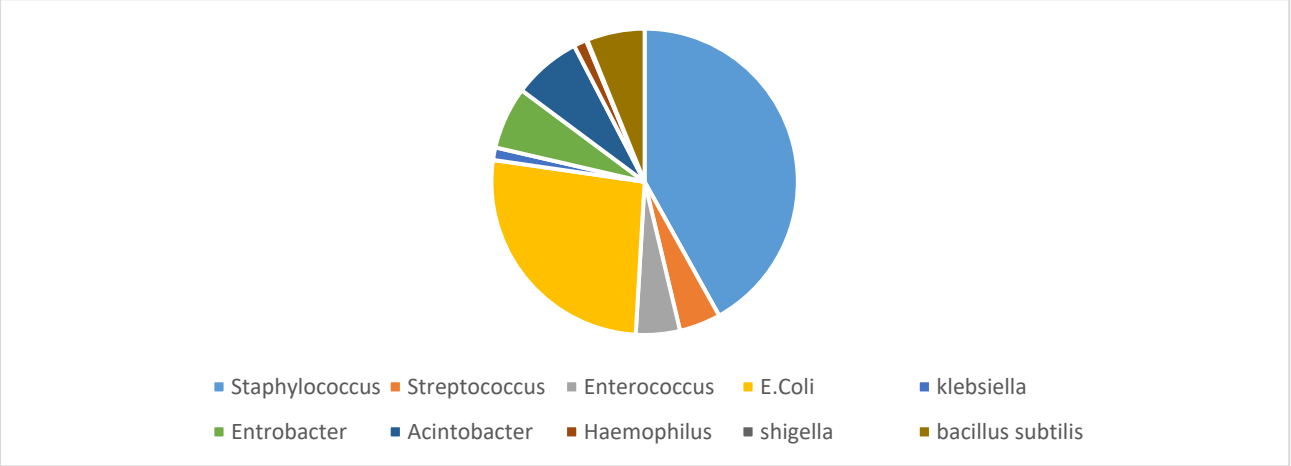


Fig-3: non-taxi transporter cars

As we can see in Table 3 and fig.3, In the pointed cars, 1 uncontaminated steering wheel, 1 uncontaminated gear, and 34 uncontaminated air conditioner vents have been reported. This vehicle does not have bus passenger handles.

Table 4: cabs

	Staphylococcus	Streptococcus	Enterococcus	E.Coli	klebsiella	Entrobacter	Acintobacter	haemophilus	shigella	bacillus subtilis	total
ext. door handles	245	37	28	231	26	47	33	19	4	37	707
	6.525	0.985	0.746	6.152	0.692	1.252	0.879	0.505992	0.106525	0.985	18.84
steering wheel	80	8	11	24	6	10	12	9	2	14	176
	2.130	0.213	0.293	0.639	0.160	0.266	0.320	0.240	0.053	0.373	4.680
gear shifter	121	12	15	97	8	17	27	8	1	16	322
	3.222	0.320	0.399	2.583	0.213	0.453	0.719	0.213	0.027	0.426	8.575
int. mirror	121	14	12	97	7	18	26	10	_	15	320
	3.222	0.373	0.320	2.583	0.186	0.479	0.692	0.266		0.399	8.522
wing mirrors lever	118	11	9	93	7	25	27	7	_	14	311
	3.142	0.293	0.240	2.477	0.186	0.666	0.719	0.186		0.373	8.282
starter switch	92	12	11	49	5	15	14	2	_	12	212
	2.450	0.320	0.293	1.305	0.133	0.399	0.373	0.053		0.320	5.646
a.c vents	52	14	10	23	_	17	21	2	_	18	157
	1.385	0.373	0.266	0.613		0.453	0.559	0.053		0.479	4.181
int . Door handle	128	11	17	122	6	22	29	3	1	18	357
	3.409	0.293	0.453	3.249	0.160	0.586	0.772	0.080	0.027	0.479	9.507
window glass lifter lever	123	10	14	121	3	23	31	_	_	25	350
	3.276	0.266	0.373	3.222	0.080	0.613	0.826			0.666	9.321
int. door lever	111	9	12	55	1	17	22	1	_	19	247
	2.956	0.240	0.320	1.465	0.027	0.453	0.586	0.027		0.506	6.578
seats	235	28	23	203	2	46	31	2	_	26	596
	6.258	0.746	0.613	5.406	0.053	1.225	0.826	0.053		0.692	15.872
bus passenger handles	_	_	_	_	_	_	_	_	_	_	_
total	1426	166	162	1115	71	257	273	63	8	214	3755
	37.976	4.421	4.314	29.694	1.891	6.844	7.270	1.678	0.213	5.699	100.000

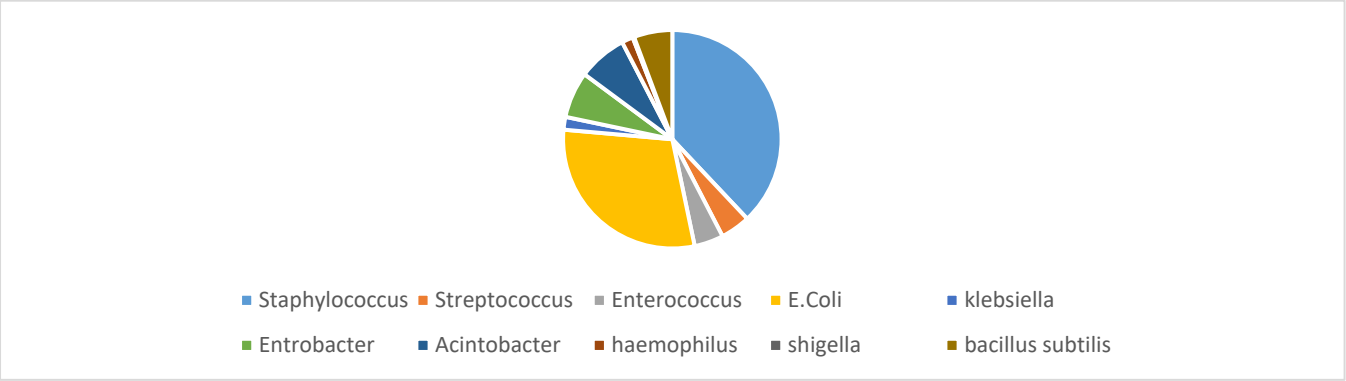


Fig-4:cabs

As Table 4 and fig.4 show us ,It should be noted that 10 uncontaminated steering wheels, 1 uncontaminated switch case, and 10 uncontaminated lever door openers were reported in cabs. This vehicle does not have a bus handlebar.

Table 5: private cabs

	Staphylococcus	Streptococcus	Enterococcus	E.Coli	klebsiella	Entrobacter	Acintobacter	haemophilus	shigella	bacillus subtilis	total
ext. door handles	75	6	7	58	6	21	30	8	_	12	223
	4.466	0.357	0.417	3.454	0.357	1.25	1.785	0.476		0.714	13.276
steering wheel	51	5	2	42	_	11	16	3	_	11	141
	3.037	0.298	0.119	2.501		0.655	0.952	0.179		0.665	8.406
gear shifter	55	6	3	42	_	9	17	2	_	8	142
	3.276	0.357	0.179	2.501		0.536	1.012	0.119		0.476	8.456
int. mirror	55	7	2	37	_	10	18	2	_	9	140
	3.276	0.417	0.119	2.203		0.595	1.072	0.119		0.536	8.337
wing mirrors lever	86	6	8	36	1	14	19	1	_	11	182
	5.122	0.357	0.476	2.144	0.059	0.833	1.131	0.059		0.655	10.836
starter switch	38	5	6	20	_	6	12	_	_	14	101
	2.263	0.298	0.357	1.191		0.357	0.714			0.833	6.013
a.c vents	47	3	_	10	_	_	12	_	_	15	87
	2.799	0.179		0.595			0.714			0.893	5.18
int . Door handle	87	5	7	37	_	13	21	2	1	12	185
	5.181	0.298	0.417	2.203		0.774	1.25	0.119	0.059	0.714	11.015
window glass lifter lever	85	5	6	41	_	15	18	1	1	11	183
	5.062	0.298	0.357	2.441		0.893	1.072	0.059	0.059	0.665	10.906
int. door lever	43	7	8	20	_	11	19	_	_	13	121
	2.561	0.417	0.476	1.191		0.665	1.131			0.774	7.215
seats	88	6	6	28	_	14	17	_	_	15	174
	5.241	0.357	0.357	1.667		0.833	1.012			0.893	10.36
bus passenger handles	_	_	_	_	_	_	_	_	_	_	_
total	710	61	55	371	7	124	199	19	2	131	1679
	42.284	3.633	3.274	22.091	0.416	7.391	11.845	1.13	0.118	7.818	100

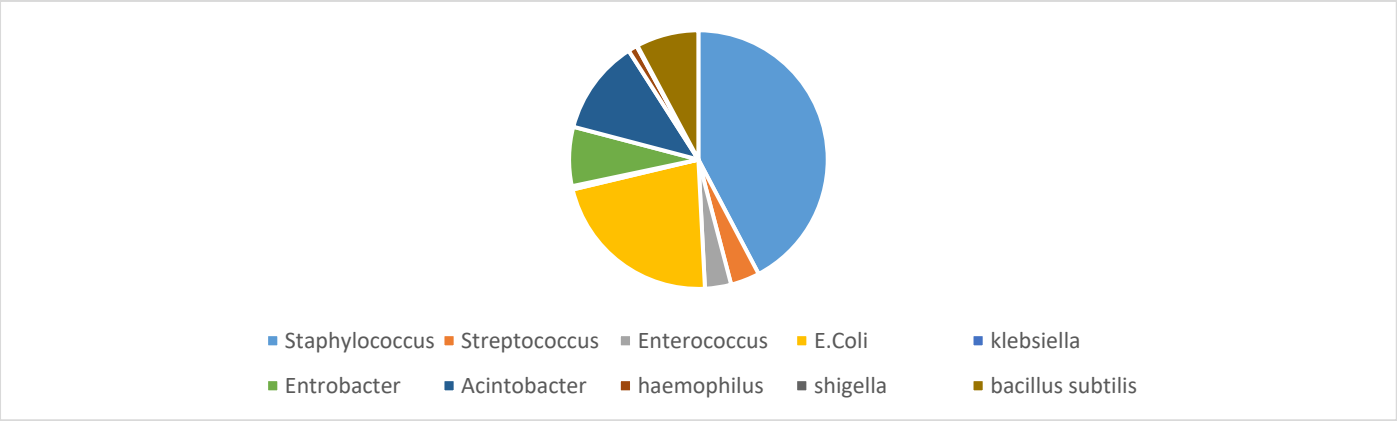


Fig.5:private cabs

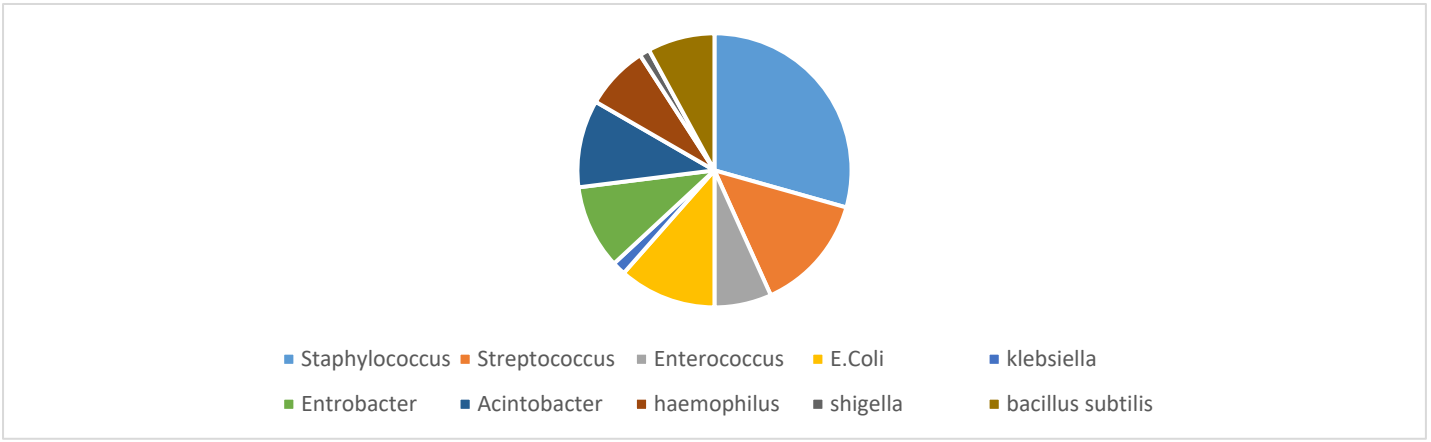
We can see in table 5 and fig.5 the contamination rates in **private cabs**

This vehicle does not have a bus handlebar.

Table 6: buses

	Staphylococcus	Streptococcus	Enterococcus	E.Coli	klebsiella	Entrobacter	Acintobacter	haemophilus	shigella	bacillus subtilis	total
ext. door handles	_	_	_	_	_	_	_	_	_	_	
steering wheel	24	8	1	3	1	3	2	1	_	3	46
	9.527	3.175	0.396	1.19	0.396	1.19	0.793	0.396		1.19	18.253
gear shifter	_	_	_	_	_	_	_	_	_	_	
int. mirror	_	_	_	_	_	_	_	_	_	_	
wing mirrors lever	_	_	_	_	_	_	_	_	_	_	
starter switch	_	_	_	_	_	_	_	_	_	_	
a.c vents	_	_	_	_	_	_	_	_	_	_	
int . Door handle	_	_	_	_	_	_	_	_	_	_	
window glass lifter lever	_	_	_	_	_	_	_	_	_	_	
int. door lever	_	_	_	_	_	_	_	_	_	_	
seats	27	11	6	14	1	12	16	6	2	8	103
	10.714	4.365	2.381	5.556	0.396	4.763	6.349	2.381	0.793	3.175	40.873
bus passenger handles	23	16	10	12	2	10	8	12	1	9	103
	9.126	6.349	3.969	4.763	0.793	3.969	3.175	4.763	0.396	3.571	40.874
total	74	35	17	29	4	25	26	19	3	20	252
	29.367	13.889	6.746	11.509	1.585	9.922	10.317	7.54	1.189	7.936	100

Fig-6:buses



We can see in Table 6 and fig.6 the contamination rates in buses .This vehicle does not have an external door handle lever, gear shift, int. mirror, hand or electric wing mirror lever, starter switch, a/c vent, int. door handle, and window lifter lever (manual or electric).

Table 7: vans

	Staphylococcus	Streptococcus	Enterococcus	E.Coli	klebsiella	Entrobacter	Acintobacter	haemophilus	shigella	bacillus subtilis	total
ext. door handles	_	_	_	_	_	_	_	_	_	_	_
steering wheel	4	1	1	3	1	1	_	_	_	1	12
	3.125	0.781	0.781	2.343	0.781	0.781				0.781	9.373
gear shifter	_	_	_	_	_	_	_	_	_	_	_
int. mirror	_	_	_	_	_	_	_	_	_	_	_
wing mirrors lever	_	_	_	_	_	_	_	_	_	_	_
starter switch	_	_	_	_	_	_	_	_	_	_	_
a.c vents	_	_	_	_	_	_	_	_	_	_	_
int . Door handle	10	2	1	4	1	4	3	1	_	3	29
	7.813	1.562	0.781	3.125	0.781	3.125	2.343	0.781		2.343	22.654
window glass lifter lever	_	_	_	_	_	_	_	_	_	_	_
int. door lever	_	_	_	_	_	_	_	_	_	_	_
seats	28	3	6	18	4	11	8	1	1	7	87
	21.875	2.343	4.687	14.063	3.125	8.594	6.25	0.781	0.781	5.468	67.967
bus passenger handles	_	_	_	_	_	_	_	_	_		_
total	42	6	8	25	6	16	11	2	1	11	128
	32.813	4.686	6.249	19.537	4.687	12.5	8.593	1.562	0.781	8.592	100

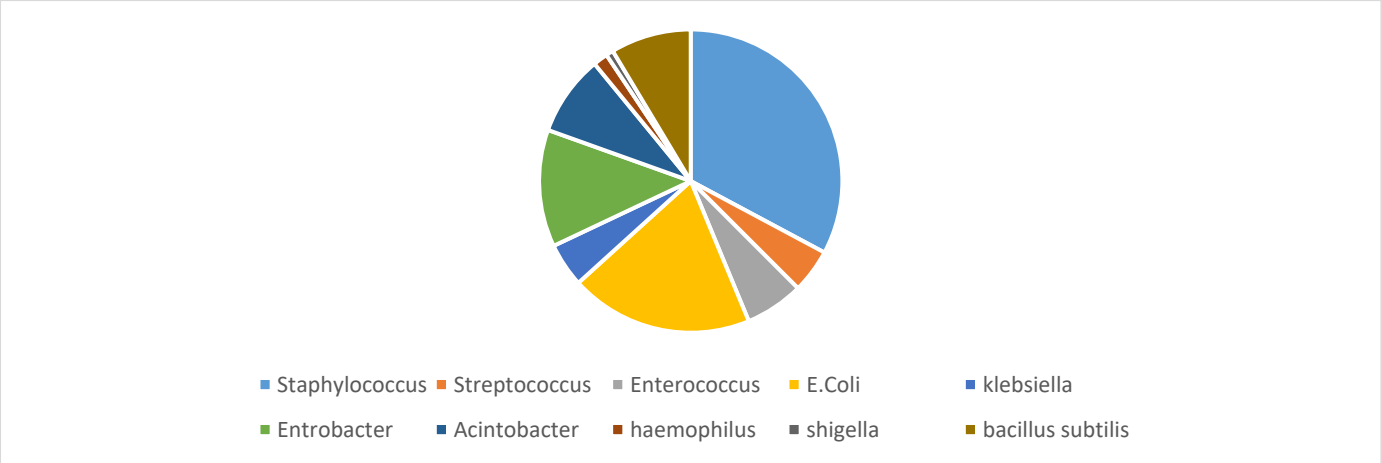


Fig.7: **vans**

We can see in Table 7 and fig.7 the contamination rates in buses This vehicle does not have an external door handle lever, gear shift, int. mirror, hand or electric wing mirror lever, starter switch, a/c vent, int. door handle, and window lifter lever (manual or electric).

Discussion & conclusion :

The graphs and data survey in this study can be analyzed from several aspects. Bacterial study of crowded vehicles, such as buses, is vital for their high traffic. Bus seats and handlebars are essential parts that can be rich in contamination. Thenceforth, the steering wheel is introduced to the driver. Because contact levels that can be contaminated and pathogenic to people are more limited on buses and vans than a cabs. the possibility of direct transmission of contamination from a vehicle seems less likely; However, it should be noted that the density of the presence of people in these vehicles is higher. The possibility of transmitting infections from person to person and the presence of bacteria in the vehicle and their density are higher.

Bacterial species of Staphylococcus are present in all vehicles, including n.t.t cars, buses, and vans. The possibility of contamination and infection is higher in buses and vans than in other studied pathogens and even in vehicles. The same goes for taxis and P. cabs.

For the van in fourth and eighth place, we see the same density for the two bacteria mentioned.

As it turns out, Staphylococcus is the most dangerous species in terms of contamination in all vehicles studied. E. coli is the second most dangerous species except for the bus. However, Streptococcus in the second place in buses are the high-risk and troublesome species. In contrast, this species ranks sixth and more in other vehicles.in table-8 we can see contamination rate compare between different vehicles.

Table-8 : contamination rate compare between

p.cabs	cab	van	bus	
Staphylococcus	Staphylococcus	Staphylococcus	Staphylococcus	**1.**
E.coli	E.coli	E.coli	Streptococcus	**2.**
Acinetobacter	Acinetobacter	Enterobacter	E.coli	**3.**
Bacillus subtilis	Enterobacter	Bacillus subtilis Acinetobacter	Acinetobacter	**4.**
Enterobacter	Bacillus subtilis		Enterobacter	**5.**
Streptococcus	Streptococcus	Enterococcus	Bacillus subtilis	**6.**
Enterococcus	Enterococcus	Streptococcus Klebsiella	Haemophilus	**7.**
Haemophilus	Klebsiella		Enterococcus	**8.**
Klebsiella	Haemophilus	Haemophilus	Shigella	**9.**
Shigella	Shigella	Shigella	Klebsiella	**.10**

Comparison of infection (bacterium-based)

Staphylococcus

According to statistics, Staphylococcus is the most common bacterium identified in all vehicles. In contact with people's hands and even handkerchiefs contaminated with nasal secretions and the contact of wounds left by staphylococcal infections, chronic bone infections, and meningitis on the surface of vehicles, there is a possibility of adhesion of these bacteria to the surfaces. This bacterium has many ways of transmission; for example, if a young woman touches her genital area without washing her hands after using the contaminated vehicle, she is more likely to become infected and get a urinary tract infection. Also, if, for example, a child puts his hand directly into his mouth after touching the surfaces of vehicles, he may suffer from food poisoning caused by this bacterium. The high percentage of contamination of different surfaces of different types of vehicles with bacteria can probably not indicate the high adhesion of bacteria of this genus to the surfaces. As a result, using appropriate methods, disinfection of surfaces of this microorganism will be essential.

E Coli

The second most common bacterium in all vehicles except busses is E. coli (this bacterium ranks third in terms of frequency on the bus). The bacteria found may be harmless or pathogenic species of this genus (although most species of this bacterium are harmless, pathogenic species can cause severe disease in humans). The high contamination of car surfaces with this bacterium is probably due to the lack of proper handwashing after contact with the anus. However, it may not be visible or stuck under the nails. Given the transmission of this bacterium, E Coli is abundant in vehicles. It can be concluded that this bacterium has high adhesion to car surfaces.

Acinetobacter

It is the third most common bacterium found in all vehicles except buses and vans, and the fourth most common bacterium in buses and vans. One of the reasons for the high level of this bacterium on the surfaces is the contact of hands contaminated with nasal secretions with vehicles. Because this bacterium is a Nosocomial bacterium, one of the causes of contamination of vehicle surfaces with this bacterium can be the contact of infected hands of the medical staff due to negligence in proper disinfection. Patients in hospitals or patient companions (especially children) may also carelessly touch devices and equipment in hospitals that have not been wholly disinfected and transmit bacteria to surfaces if vehicles are used. These bacteria are not transmitted through the air. However, they can

be infected in contact with people's skin with contaminated surfaces or vehicles.

Streptococcus

The importance of surface contamination with this bacterium is more important in buses. According to the collected statistics, the percentage of bus contamination with this bacterium is high than in other vehicles. It has the second place in terms of frequency in buses, While in other vehicles, it has a low to moderate frequency. People with this bacterium can contaminate these surfaces if they touch their nose, skin lesions, or sores and then touch the surfaces of vehicles because one of the ways of transmitting this bacterium is through air molecules. The infected person may spread this bacterium in the air through coughing and sneezing and without covering his nose and mouth. Through the air, molecules of this bacterium stick to the car's surfaces.

As a result, other people may be at risk for infections caused by this bacterium by hand contact with these surfaces and then touching the nose, mouth, genitals, and anus. Alternatively, the bacterium may even be transmitted directly to other people through the sneezing and coughing of an infected person. Given that most people who use buses for their daily commute are from the middle class and may not have a high economic status and level of awareness of health issues, these people may be committing unsanitary actions, such as sneezing without the use of wipes, leading to contamination of surfaces with this bacterium for to lack of awareness. Therefore, advertisements and billboards installed in the streets can play a significant role in informing this group about the issue to observe the necessary hygienic points when using public vehicles.

Shigella

This bacterium had the lowest percentage of all vehicles studied in this study. Perhaps this

reflects the fact that vehicles are not the usual means of transmission of this bacterium and do not play a significant role in the transmission chain of this bacterium. It is also possible to conclude the low surface adhesion of the bacteria. However, there is no guarantee that you will not get infected with Shigellosis and its complications in vehicles, but the chances are meager.

Evaluation of the transmission of airborne bacteria via air vents:

The distribution of microbes is different depending on their mode of transmission. Therefore, the assessment of airborne bacteria is of great importance. One way that contributes to the spread of these bacteria, is airflow through air vents.

Table-9 shows us this evaluation.

Table-9: **Evaluation of the transmission of airborne bacteria via air vents**

	staphyl c	**strpto c**	**enteroc**	**E.coli**	**Klebsiella**	**Enero B**	**Acineto**	**Haemo**	**shigella**	**BS**	**uncontaminated**	**total**
n.t.t car	148	28	18	76	_	33	36	2	_	42	34	417
percent	0.355	0.067	0.043	0.182	_	0.079	0.086	0.005	_	0.101	0.082	1
Cab	52	14	10	23	_	17	21	2	_	18	_	157
percent	0.331	0.09	0.064	0.146	_	0.108	0.134	0.013	_	0.114	_	1
p.cab	47	3	_	10	_	_	12	_	_	15	_	87
Percent	0.54	0.035	_	0.115	_	_	0.138	_	_	0.172	_	1

The table above shows the comparison between different air vents:

1. (Staphylococci are airborne bacteria that can be transmitted through the air and respiratory aerosols. The achieved results indicate that Staphylococci are

responsible for most of the bacterial contaminations in air vents. [1]

Streptococci can be transmitted through either aerosols or direct contact, but aerosol transmission is not the main mode of transmission for these organisms. As the results confirm, streptococci do not play a major role in contaminating air vents.[2]

2.

Regarding the fact that Enterococci are intestinal bacteria , they have to be transmitted through the oral pathway, by touching objects that are contaminated with the stool of an infected person. Thus, as expected, results show that Enterococci do not have a noticeable impact on the microbial contamination of air vents.[3]

E coli bacteria are foodborne and waterborne germs. The intestine is the target organ of E Coli; Therefore, they cannot be transmitted through the air. Although the results show that air vents might be slightly contaminated with E Coli, it is not of great significance.[4]

3. (From the journal related to klebsiella)

Klebsiella is nosocomial bacteria and is spread by person-to-person contact. Therefore, aerosol transmission is not usually a suitable way for their distribution. As we can see in the provided data, contamination by these organisms in all of the assessed air vents was zero.[5]

4. (From the journal related to Enterobacter)

Enterobacter species are transmitted via blood or injections. Results show that the Enterobacter genus constitutes only a little portion of the contaminated air vents.[6]

Although Acinetobacter species are nosocomial bacteria and are usually disseminated through person-to-person contact or contact with contaminated objects, they can also be transmitted via aerosols. Therefore, air vents are a possible way of transmission for these organisms.

An interesting finding was that the number of contaminated air vents by Acinetobacter was almost as high as that of Enterobacter.[7]

Hemophilus can be spread via air, respiration, and oral and nasal secretions. However, as the results indicate, these bacteria contaminated a very low number of air vents.[8]

Bacillus subtilis is an airborne bacterium; Hence, air vents are a suitable way of transmission for this organism. As findings revealed, the number of air vents contaminated by this bacterium is higher than that of Haemophilus and Klebsiella. [9]

5. Shigellae are a member of the Enterobacteriaceae family, which are spread by oral pathways. People get exposed to these bacteria by consuming contaminated food, or water, and the symptoms are shown after the entrance of bacteria into the gastrointestinal tract. For that reason, aerosol transmission is relatively ineffective for these bacteria. The number of air vents contaminated by shigellae in all the vehicles studied was zero.[9]

In a general view, by evaluating the charts and the examination results, we determined that:

1. Staphylococci have the highest rate of air vent contamination.
2. We cannot give an absolute opinion regarding the lowest rate of contamination because the number is different depending on the type of vehicle. But generally, there's no need to be concerned about the aerosol transmission of Haemophilus and Klebsiella via air vents.
3. In all the vehicles examined, the total rate of microbial pollution in the air vents makes up about 4-5% of the contaminations. So, in a general outlook, there's no reason to worry about the contamination of air vents by airborne bacteria.

Susceptible groups:

Diabetics and alcoholics are at higher risk of developing a serious illness along with more severe symptoms if they get infected by Klebsiella and Acinetobacter. Both bacteria have a high level of distribution in public transport, especially on the exterior door handles. Hence, it is safer for these people to wear a glove whenever they intend to touch the door handle.

Streptococci have more devastating impacts on people with underlying diseases such as cardiopulmonary disease or upper respiratory infection (URI). According to the data gathered, Streptococci are more common in buses, compared to other vehicles. Therefore, we recommend the mentioned population use other means of transportation. Just like Klebsiella and Acinetobacter, Streptococci have also a higher distribution on the exterior door handles of public transport, so it is necessary to open these doors with regard to personal hygiene protocols. Washing hands constantly, using sanitizers, avoiding touching the face, and in a few instances, avoiding touching genital and rectal areas are other means of prevention.

Haemophilus bacteria are an important cause of meningitis in children. The probability of transmission of these bacteria in crowded areas and on public transport, especially on buses, is very high if children are not vaccinated with the Haemophilus b conjugate vaccine.

Difference between passenger and driver in contamination threat

Staphylococcus

As mentioned earlier Staphylococcus Had the highest level of contamination in vehicles.

Constantly, the exterior door handle was the most contaminated surface in p.cabs, surplus, everybody uses door handle passenger and driver.

In the cabs, n.t.t cars and p.cabs Generally, the surface that drivers contact with had the least amount of Staphylococcus, e.g, starter switch, wheel, gear handle.

The van just the wheel was evaluated, it had meaningfully lower contamination.

Pathogenicity of Staphylococcus isn't a serious problem for the other surfaces are used communally.

In the bus, Although the grab handle is used by lots of passengers, It was less polluted than the wheel, therefore, assessing the pathogenicity of Staphylococcus on passengers is as vital as the driver.

Streptococcus

In n.t.t cars, vans, cabs, p.cabs, contamination of surfaces that are touched by passengers & drivers is the same.

In the van and cab contamination rate is quite low. In the bus, the amount of Streptococcus on the grab handle is two times more than the amount of Streptococcus on the steering wheel. Therefore, passengers are meaningfully more at risk than drivers.

Enterococcus

In the bus, the numbers of Enterococcus on the grab handle are more than on the wheel, thus, obviously, passengers are threatened with more.

In p.cabs, cabs, vans, nearly, surfaces that have the lowest contamination, e.g., gear shift, switch, and int. mirror. it shows that drivers are more in safety.

E.Coli

In private cars and taxis, surfaces that are related to drivers, wheel, gear handle, and switch have the fewest defilement but as another communal surface between driver and passengers are the same, surplus, E.Coli has a high infection, nearly, there is no difference between passengers and drivers in the van and p.cab.

In the bus, the grab handle is more polluted than the wheel, thus, passengers are more in danger.

Klebsiella

In n.t.t cars, cabs, p.cabs, vans, approximately infection of surfaces is the same.

In the bus, the grab handle and the wheel had the same contamination.

So, passengers and drivers get equal threats.

Enterobacter

private cars, on surfaces that are related to the drivers, have the lowest pollution.

Other surfaces that are touched by drivers and passengers too are the same.

In the cab, p.cab, van, passengers, and drivers have the same risk.

On the bus, the number of Enterobacter on the grab handle is three times more infected than on the wheel, therefore, passengers are threatened more than drivers.

Actinobacteria

In private cars, the lowest polluted surfaces were touched by drivers, wheel, switch, and gear handle.

In-cab, van, and p.cab, contamination rates of surfaces were all the same. The driver is as unsafe as the passenger.

Haemophilus

In taxis, and private cars, the number of Haemophilus on the gear handle wheel was enormous, thus, the driver is threatened with more. On the bus, the gear handle was more polluted than the wheel, consequently, passengers are more vulnerable to Haemophilus. In the van, the passenger is as insecure as the driver.

Bacillus subtilis

In private cars, surfaces touched by the driver, wheel, gear handle, and switch had the lowest contamination.

Other surfaces that were touched by the driver were polluted as surfaces that touch by passengers.

In tcabs , p.cabs , vans, the number of Bacillus subtilis was the same.

in the bus contamination rate on the gear shift was triple toward the wheel therefore passengers are more in danger.

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