The Epidemic: a Large Group Activity That Demonstrates Transmission of Infectious Agents

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Abstract

This activity describes a simulated epidemic using the nontoxic, noninfectious, fluorescent agent GloGerm. Students rub gauze saturated with mineral oil on a gloved hand; one student in the class has oil containing GloGerm. The students then proceed through three to five controlled rounds of handshaking, recording each "encounter." After the last round of handshakes, the spread of the epidemic is traced by recording the "infected" glowing hands, detectable by ultraviolet light. The students share and analyze the data from the rounds of handshakes and trace the transmission of the agent, GloGerm, back to patient zero.

Activity

Invitation for User Feedback. If you have used the activity and would like to provide feedback, please send an e-mail to MicrobeLibrary@asmusa.org. Feedback can include ideas which complement the activity and new approaches for implementing the activity. Your comments will be added to the activity under a separate section labeled "Feedback." Comments may be edited.

Learning Objectives.

At the end of this activity, students will be able to:

- recognize how easily an epidemic can start,
- understand the exponential nature of incidence of infection in an epidemic scenario, and
- be able to critically analyze the data generated (determine who patient zero is).

Background.

No background is necessary; however, the exercise is most valuable with prior introductory definitions of epidemiology and epidemics.

Materials.

- One petri dish per student, numbered in consecutive order, containing a gauze pad or cheese cloth. The cheese cloth should be saturated with a mineral oil and cornstarch solution. One petri dish should have mineral oil plus GloGerm powder instead of mineral oil and cornstarch. The exact concentration of GloGerm or cornstarch doesn't matter, if the solution looks white, there is enough in there. GloGerm can be ordered through the Internet.
- Gloves, one per student
- Ultraviolet light (preferably UVC)
- Safety glasses
- An "isolation box," easily constructed out of the cardboard separators from petri dish boxes (see Instructor Version)

Student Version.

Please see handouts.

Student handout is the instruction sheet for students.
Data table 1 is an example arrangement of a data table that would be appropriate for smaller classes of 12 to 20 students.
Data table 2 is an example arrangement of a data table appropriate for larger groups of students, in which a limited testing of infection is done midway through the exercise.

Instructor Version.

Preparation of petri dish "inoculants"
Label petri dishes sequentially, one per student participating, and place a gauze pad or gauze-pad-sized piece of cheese cloth in the dish. Pour 10 to 20 ml of either mineral oil plus cornstarch or mineral oil plus GloGerm onto the gauze. Only one petri dish should contain oil plus GloGerm. The cornstarch and oil in the "noninfectious" petri dishes eliminates the possibility that students will compare the turbidity of the residual oils in the dishes and cheat to determine who patient zero is. GloGerm is a nontoxic fluorescent powder that can be ordered through the company website. The company also has oil-based GloGerm available; however, we have only used the powder form.

Prior to starting the exercise
Students are given one latex glove, a set of instructions, and one petri dish with gauze, as described above. Several directions are key at this point. First, it is important that the students follow instructions for putting the glove on their nonwriting hand and that they only touch the gauze pad with the gloved hand (the oil is pretty messy otherwise). Second, it is important that students DO NOT shake hands before instructed. Controlling the handshake rounds ensures that students do not shake hands with someone they have previously encountered, making the tracing to patient zero difficult. All pairs should be established prior to anyone touching in a given round. (This can actually lead to some humorous situations with the course instructor standing up at the front of the room, waving his or her arms, and "conducting" The Epidemic.)

Use standard, yellow, nonpowdered latex gloves because they allow visualization of the powder. For one rendition of the activity, the class was joined by friends to increase the number of participants, and those volunteers supplied their own blue nonlatex gloves (they were Rescue Squad members). It was easy to see heavy amounts of inoculants on the blue gloves, but it was difficult to see small amounts. Additionally, some gloves are manufactured with imperfections or flecks of particles which fluoresce. These "false positives" look very different from GloGerm fluorescence. False positives are often a single distinct bright dot, while GloGerm is dispersed and powder-like with numerous smaller and fainter fluorescent spots. Thus, it is recommended that you test your gloves with the UV light to see what they look like prior to the activity. Viewing a few representative gloves prior to the activity will give you a sense of the false positives.

During the exercise
The number of handshaking rounds depends on the number of students in the course. After "n" rounds of contact, there can be as many as 2^n "infected" individuals. Aim for most of the class to be infected (3/4 to 4/5). It is expected that some infected individuals will shake hands with previously infected individuals, so it is unlikely that the maximum number of infections (2^n) will occur. Because of false positives and negatives, blind testing of five students' hands at round three is recommended. The additional data from this testing may be needed to determine patient zero, and this can be provided to students after the final testing for infected individuals. We have conducted this activity three times with four handshake rounds for 14 students and 5 handshake rounds for 24 and 28 students. With the larger groups of students, we randomly tested five individuals after round three, but did not allow them to know their status at that point!

Students can get exuberant shaking hands with oily latex gloves, especially if they are given the instruction, "Make sure your handshaking partner's hand is fully exposed to whatever is on your glove." While exuberant handshakes provide much humor to the class, the additional spread of the GloGerm to the backs of the gloves makes visualizing the powder a little difficult, as it was spread over a greater surface area. Future renditions of this activity by the authors will include the instruction, "Handshakes are supposed to be standard handshakes—please to not attempt to inoculate the backs of your partners' hands."

Testing for infection
Set up a testing station using a free-standing UV lamp surrounded by cardboard. Create a hole for students to stick their hand in and be tested midexercise without them being able to see the results. At the completion of the handshaking rounds, remove some of the cardboard. Students can visualize their own hands and record who has become infected. Images are provided (Appendix A). The GloGerm website offers some interesting alternates to the UV light source, including a UV flashlight that works in full room light. We had to dim the lights to fully see the fluorescent powder, unless the cardboard blocked the ambient light.

Don't forget who you have set-up as patient zero! False positives (fluorescent specks) or false negatives (fluorescence too low to detect) may make it challenging for your students to figure out who was patient zero. It may be necessary for you to "correct" some data to help them fully determine the transmission. Of course, this opens the door to an interesting conversation about false negatives or positives in real-world tests.

Suggestions for determining student learning
Assessment of the exercise consisted of 12 questions (multiple choice and short answer) that addressed two areas: (i) the students' understanding of epidemics and (ii) the students' opinions of the exercise itself. A copy of the survey is included (Appendix B).

An alternate assessment possibility is a written journal assignment. Appendix F is a student journal entry from the biology majors class. Students are required to keep a weekly journal recording "the impact of microorganisms on their lives," and following The Epidemic exercise, one student chose to comment on what she had learned from the experience.

Additional notes
Please see "Possible Modifications" for a discussion of the differences between a GloGerm simulation and a real-world epidemiological study and for potential activities to take advantage of those differences to further student understanding of epidemiology.

Safety Issues.

UV light is a safety hazard, therefore proper eye protection should be used.

Field Testing.

Course conditions
The How Your Body Works class is a biology course for first-year nonbiology majors (hereto referred to as the nonbiology majors class). The class had been studying sexually transmitted diseases and their higher rates of occurrence on campuses than in the general population. Prior to the exercise, the class was assigned to read two pages in their textbooks (1) that defined epidemiology and epidemics. The class consisted of 16 students with interests ranging from biology and chemistry to fine arts. For this exercise, 14 of the 16 students were present, and 12 of the 14 students completed the assessment of the exercise.

The General Microbiology class is a biology course for upper-level biology majors (hereto referred to as the biology majors class). The class did not have any prior lectures or assignments related to the topic of epidemics. The class consisted of 12 students with interests in various biology-related careers such as human medicine, veterinary medicine, laboratory research, and field work. The students were asked to bring friends to participate in the exercise. A total of 28 students participated, and 11 students from the class completed the assessment of the exercise.

Assessment—knowledge of epidemics
For the nonbiology majors class, 58.3% of the students correctly chose the example that illustrated an epidemic. 100% correctly choose that it takes one round of transmission to start an epidemic (not five or one thousand). For the biology majors class, only 27.3% of the students chose the correct example of an epidemic. Only 45.5% of the students correctly identified that one round of transmission could start an epidemic. The higher proportion of students identifying an epidemic and how it starts (a learning outcome) in the nonbiology majors class demonstrates that even at an introductory biology level, the exercise, in conjunction with a prior assignment or lesson on epidemics, can reinforce student understanding of how easily an epidemic can start.

Assessment—opinions of the exercise
When asked if The Epidemic exercise helped illustrate how an epidemic starts, the majority of the students in both classes indicated “yes, very well” (91.6% and 81.8%, respectively). Later in the assessment the students were asked for written opinions of the exercise. Overall, 11 students from both classes commented on the start and the spread of the disease as the most helpful or interesting part of the exercise. This is expressed in one student’s comments “…seeing how fast the powder was spread between all the people in a short time. It was interesting to see how many people contracted the disease in a small number of rounds.” Several students were able to extrapolate the results from the exercise and relate it to potentially real situations, as seen in the comment from a student in the nonbiology majors class “…that any disease can be spread to thousands in a short time.” These comments demonstrate that the exercise helps students understand the exponential nature of incidence of disease in an epidemic scenario.

When asked if The Epidemic exercise helped illustrate how an epidemic can be traced, 83.3% of the students in the nonbiology majors class selected “yes, very well.” The students in the biology majors class were split between “yes, very well” and “maybe.” Out of both classes, seven students considered filling out the grid and tracing the epidemic to the initial carrier as the most helpful or interesting part of the exercise. In the nonbiology majors class, almost everyone was able to determine who the carrier was within 5 minutes. The class as a whole very enthusiastically shared their deductive skills with the two who did not determine the carrier, and, as a group, they helped those people finish the tracing. In the biology majors class, more people were involved in the exercise, the transmission was carried out to five rounds, there was a random check at round three, and the class experienced several false positives. A higher-level of critical analysis was needed in order to determine who the primary carrier was. This explains the discrepancy in views of how the exercise illustrates how an epidemic can be traced that was noted between the classes. Overall, both classes were able to critically analyze the data to determine patient zero.

The students were also asked to comment on what part of the exercise was least helpful or interesting. The main negative comments were about the feel of the oily gloved handshake. Otherwise, students commented on what they found disturbing, such as “…the possibility that no’s are not actually no’s.” Both classes had either false positives or false negatives. This provided a great topic of discussion: the realities of testing procedures.

The majority of students in both classes indicated that they learned something new (91.6% and 72.7%, respectively). 100% of all students in both classes recommended the exercise for next year. Students' comments included “Interesting exercise!” and “I thought this was insightful.”

Overall, the students’ assessments indicated that they had a positive experience and that they were able to master the learning outcomes of (i) recognizing how easily an epidemic can start, (ii) understanding the exponential nature of incidence of disease in an epidemic scenario, and (iii) critically analyzing the data generated to determine patient zero.

Student Data.

Please see the attached data sheets. False positives and negatives from Data Set 1 (Appendix C) were corrected, and the solution (Appendix D) indicates who was infected at which round. Data Set 2 (Appendix E) contains two false negatives (person 1 and 2 should be infected following round 4). Interestingly it is possible to determine patient zero (person 4) with the incorrect results, but not with corrected results. This class choose not to determine if three or four random people were infected following round 3. One way for an instructor to correct such a data set so that it may be analyzed correctly would be to provide hypothetical round three infection data.

Appendix C. Data Set 1
Appendix D. Data Set 1 solution
Appendix E. Data Set 2

SUPPLEMENTARY MATERIALS

Possible Modifications.

Representative data is included (Appendices C–F), so instructors could use the data alone as a critical analysis exercise without actually having the students generate their own data.

We indicated that this is appropriate for laboratories, but at less than an hour in length, it can easily be incorporated into a lecture period. Additionally, it would be possible to discuss epidemics for half of a lecture period, and then complete the rounds of handshaking during the remainder of the period. The data could be collected, compiled by the faculty member, and distributed to the class for individual analysis.

This activity would also be appropriate as a get-to-know-you activity at the beginning of the semester, or as a way to demonstrate why it is important to wash hands and prevent the spread of infectious agents.
This exercise is a simulation of a real-world epidemic, and as such, shares elements with that real-world scenario, such as the exponential increase in infected individuals. However, there are also several aspects of the simulation that differ from a real epidemiological study of an infectious disease outbreak, including, but not limited to, differences in transmission rates, incubation periods, recovery, exposure levels, testing accuracy, reporting, etc. The transmission rate of GloGerm is very close to 100%, a rate that is rarely seen in real-world epidemics. Additionally, there is no incubation time in our simulation, and no recovery. Students can be asked to identify and critically analyze these distinctions between the simulation and a real-world study in the context of their data. For example, how would the number of infected individuals change in each round if the transmission rate were 50%? 25%? 1%? How would the number of infected individuals change in each round if there were an incubation period of one round? Two rounds? How would recovery impact the number of infected individuals?

To test these predictions, students could build infection models using modeling programs such as STELLA or VenSim or with graphing calculators. VenSim provides a version of its software (VenSim PLE) free to educators at its website. Using VenSim PLE, students can build Susceptible–Infected–Recovered (SIR) models using simple shapes to represent SIR populations and relationship definitions (e.g., infection rate, recovery rate, exposure, susceptibility). They may then use the models to graphically represent their data and test predictions by altering transmission rate, recovery rates, etc.

The acquisition of data in this GloGerm simulation is very different from what is faced by epidemiologists tracking real outbreaks. For example during analysis, students have all data on all infected individuals, whereas an epidemiologist may not have complete data sets. There are many challenges faced by epidemiologists in the collection of data, and often data sets are incomplete. Using the ease at which students have access to their data as a starting point, students may be asked to identify or brainstorm challenges that would be faced if they were collecting data related to a real outbreak. Students may be asked to identify patient zero using data they have generated, followed by a simulation with an incomplete data set; subsets of the provided data could be given to students to mimic an incomplete data set.

Reference.

1. **Mader, S.** 2006. Human biology, 9th ed. McGraw Hill, New York, N.Y.

Appendices and Answer Keys.

Appendix A. Images
Appendix B. Student assessment questions
Appendix C. Data Set 1
Appendix D. Data Set 1 solution
Appendix E. Data Set 2
Appendix F. Student journal entry

THE EPIDEMIC

Did you know…

In 1918, a pandemic outbreak of influenza killed between 20 and 40 million people.

The Armistice Day celebration of the end of the war on November 11, 1918 with public parades and parties restarted the epidemic in the U.S. Over one-quarter of the U.S. population became infected and over 500,000 individuals died.

INTRODUCTION

We will simulate an **epidemic** or widespread outbreak in our population (classroom). Everyone in the classroom will be given mineral oil, however, one person will have mineral oil that is contaminated with GLOGERM. GloGerm is nontoxic, and it is NOT a microorganism (bacteria or virus). It fluoresces or glows under ultraviolet (UV) light.

Epidemiology is the study of the occurrence, distribution, and control of disease in a population. We will trace the epidemiology of the epidemic by using GloGerm as our tagged "microorganism" and trace the transmission of an infectious agent. You can easily see if you have been "infected" by viewing your hand under UV light (You must wear eye protection, though, to shield your eyes from harmful UV rays).

The objectives for this laboratory are to investigate the following topics:

- epidemics
- epidemiology

INSTRUCTIONS

1. Put a glove on your non-writing hand.
2. Collect one petri dish containing mineral oil on gauze, per person.
3. Pick up the gauze from your dish with your gloved nonwriting hand.
4. Work the oil around in your palm—**without using your other hand**.
5. Put the gauze back into the dish.
6. Go through a round of handshakes, **as directed by the instructor.**
   Make sure that your hand **REALLY** contacts the other person's hand.
   Use your gloved hand only. Please do not inoculate the back of your partner's hand.
7. Record the number and name of who you shake hands with in the chart below.
8. Continue with the handshake rotations, **as directed by the instructor.**
9. After all handshakes, do not touch anything or anyone else.
10. Wait for the instructor to view your hand under the UV light.
11. Record the numbers of those people infected with the GloGerm.
12. Solve for the person who started the epidemic using the provided data table.

Handshake Rotations

Rotation no.	Handshaker's no.	Handshaker's name
1		
2		
3		
4		
5		

The Epidemic: Data Table

The Spread of the Epidemic

Person	Round 1	Round 2	Round 3	Round 4	Infected?
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Who started the epidemic? _____

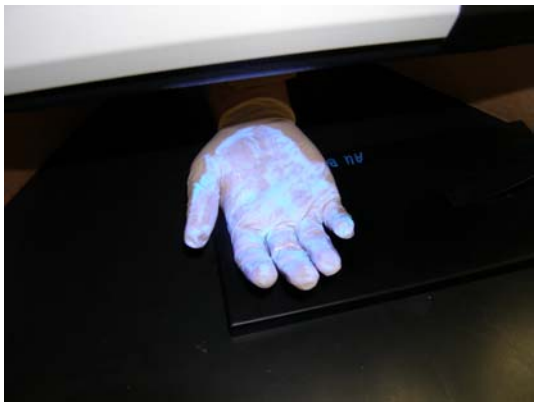
The Epidemic: Data Table

Person & dish no.	Handshaking with person no.					Infected	
	Round 1	Round 2	Round 3	Round 4	Round 5	After 3?	After 5?
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							

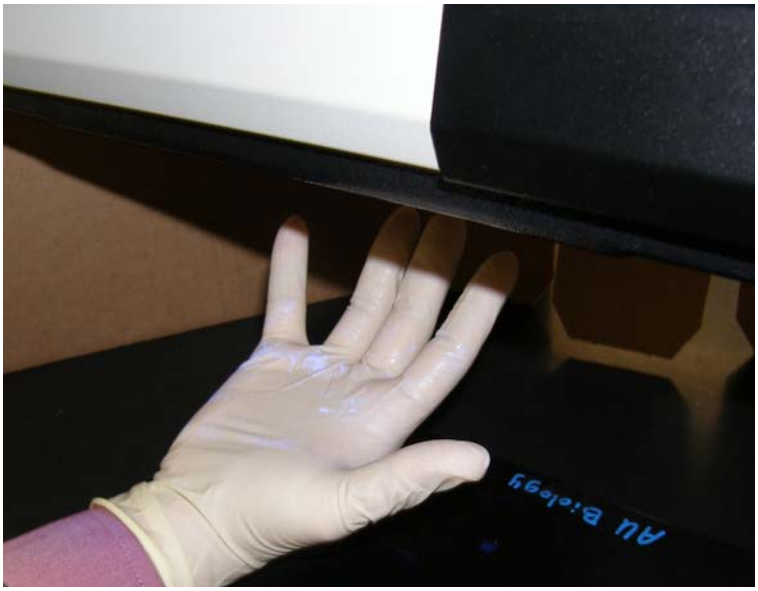
Appendix A. Images

Our testing station
Prior to the final round, cardboard inserts are arranged around a UV lamp, so only the faculty member can determine if a student's hand is fluorescing. Following the final round, the cardboard is removed, and students inspect their hands.

A freshly inoculated hand
There should be enough GloGerm and oil on the gauze pad so that patient zero's hand is covered with dye. This individual had about ¼ to ½ teaspoon of GloGerm shaken onto a pre-oiled glove.



Following round 5…
There is still sufficient fluorescent powder on the glove for visualization.



Appendix B. Student assessment questions

Course: _____Name: _____

Assessment Questions

Circle ALL answers that may apply.

Which example illustrates an epidemic?

a) a higher rate of incidence of an STD on a college campus than in the general population
b) a case of SARS in the US
c) a high number of cases of food poisoning from *Escherichia coli*

How many rounds of transmission would it take to start an epidemic?

a) one
b) five
c) thousands

Do you think it is possible to trace the origins of an epidemic that involves 20 million people in an Asian country?

a) yes
b) no

Do you think it is possible to trace the origins of an epidemic that involves 20 million people in North America?

a) yes
b) no

What is a major factor in the transmission of an infectious agent so that the disease rate reaches epidemic proportions?

a) unsanitary conditions
b) government policies
c) high population density

Did today's exercise help illustrate how an epidemic starts?

a) yes, very well
b) maybe
c) no, not very well

Did today's exercise help illustrate how an epidemic can be traced?

a) yes, very well
b) maybe
c) no, not very well

Did you learn anything new?

a) yes
b) no

Would you recommend this exercise for next year?

a) yes
b) no

What part of the exercise was most helpful or interesting?

What part of the exercise was least helpful or interesting?

Feel free to add your own comments:

Appendix C. Data set 1

The Epidemic
Record of handshaking contacts and infection outcomes

	Handshaking contacts: Round					Infected	
Person	1	2	3	4	5	After round 3[a]	After round 5
2	23	16	22	8	34	Yes	Yes
5	33	29	30	27	8		Yes
8	9	22	31	2	5		Yes
9	8	31	16	33	11		No
10	34	19	33	30	22	No	Yes
11	17	27	19	34	9		No
12	18	17	26	20	14		Yes
13	31	28	14	26	23		Yes
14	28	20	13	31	12		Yes
15	22	23	17	18	32		Yes
16	32	2	9	28	33		No
17	11	12	15	23	26		Yes
18	12	26	32	15	20		Yes
19	27	10	11	31	28		No
20	26	14	28	12	18		Yes
22	15	8	2	29	10		Yes
23	2	15	27	17	13		Yes
26	20	18	12	13	17		Yes
27	19	11	23	5	29	Yes	Yes
28	14	13	20	16	19		No
29	30	5	34	22	27	No	Yes
30	29	34	5	10	31		Yes
31	13	9	8	14	30		Yes
32	16	33	18	19	15		Yes
33	5	32	10	9	16		No
34	10	30	29	11	2	No	Yes

[a] Blank rows were not tested after round 3.

Appendix D. Data set 1 solution

The Epidemic
Record of handshaking contacts and infection outcomes

Red indicates a positive individual. Person 22 was patient zero.

	Handshaking contacts: Round					Infected	
Person	1	2	3	4	5	After round 3[a]	After round 5
2	23	16	22	8	34	Yes	Yes
5	33	29	30	27	8		Yes
8	9	22	31	2	5		Yes
9	8	31	16	33	11		No
10	34	19	33	30	22	No	Yes
11	17	27	19	34	9		No
12	18	17	26	20	14		Yes
13	31	28	14	26	23		Yes
14	28	20	13	31	12		Yes
15	22	23	17	18	32		Yes
16	32	2	9	28	33		No
17	11	12	15	23	26		Yes
18	12	26	32	15	20		Yes
19	27	10	11	31	28		No
20	26	14	28	12	18		Yes
22	15	8	2	29	10		Yes
23	2	15	27	17	13		Yes
26	20	18	12	13	17		Yes
27	19	11	23	5	29	Yes	Yes
28	14	13	20	16	19		No
29	30	5	34	22	27	No	Yes
30	29	34	5	10	31		Yes
31	13	9	8	14	30		Yes
32	16	33	18	19	15		Yes
33	5	32	10	9	16		No
34	10	30	29	11	2	No	Yes

[a] Blank rows were not tested after round 3.

Appendix E. Data set 2

The Spread of the Epidemic
Record of handshaking contacts and infection outcomes

Person	Round 1	Round 2	Round 3	Round 4	Infected?
1	5	9	2	10	No
2	8	10	1	3	No
3	4	8	9	2	Yes
4	3	7	5	9	Yes
5	1	6	4	8	Yes
6	7	5	11	12	No
7	6	4	14	13	Yes
8	2	3	10	5	Yes
9	10	1	3	4	Yes
10	9	2	8	1	Yes
11	12	13	6	14	Yes
12	11	14	13	6	No
13	14	11	12	7	Yes
14	13	12	7	11	Yes
15					
16					

Who started the epidemic? _____

Appendix F. Student journal entry

This journal entry was submitted by an upper-level student as part of a weekly journal assignment. Students are asked weekly to write a page about the impact of microorganisms on their everyday lives.

"In Alfred I noticed that a lot of people share drinks, cigarettes, and other things like food with people they don't even know. Which kind of grossed me out before this class, but now I find it repulsive. There are millions of germs and viruses in your mouth. I know all of these are not bad but some are. The bad ones are getting carelessly spread around from person to person. We did the epidemic this week after lab and that shows how fast something can pass from one person to another. I shook hands with only 5 people and still got infected. It wasn't like only 5 people got infected, almost the whole group was. This is extremely scary and makes me want to never touch anyone. So where I am going with this journal is basically how unaware people are about how unsafe they are with simple everyday things that they do in life. Giving that stranger a drag off of your cigarette, did you know where they were last night, or what they were doing? Chances are you have no idea; maybe that person has been with 150 people in their life so far. How clean can they be? Research has been done on the germs in the mouth, showing that there are more germs than what was thought to be in the mouth. "Even though almost 500 bacterial strains have been identified already, Relman believes this may be only a fraction of the bacteria living in this oral groove." That's a lot of bacteria in one place and they think that there is even more to be found. So now a day I don't share anything with anyone. I have enough germs I don't want anyone else's. My suggestion to everyone is not to share and to be greedy."