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DETERMINATION OF E. COLI CONTAMINATION ON KEYBOARD AND MOUSE AMONG UNIVERSITY STUDENT

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DETERMINATION OF E. COLI CONTAMINATION ON KEYBOARD AND MOUSE AMONG UNIVERSITY STUDENT

BY

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Thesis submitted in fulfilment of the requirement for the degree of Bachelor Science (Environmental and Occupational Health) from the Faculty of Medicine and Health Sciences, University Putra Malaysia.

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ABSTRACT

DETERMINATION OF *E. COLI* IN KEYBOARD AND MOUSE AMONG UNIVERSITY STUDENT

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Introduction: Computer has become as one of the important tools in higher education. Computers are widely used in computer laboratory, printing shops and library to access to internet to obtain information resources. Most of these locations are generated for multiple user computers. As the population of such facility increases, the computer acts as a reservoir for the transmission of potential pathogenic bacteria such as *E. coli*. **Objective:** The aim of this study is to determine and compare *E. coli* contamination in keyboard and mouse at different locations (printing shops, computer laboratory and library). **Methodology:** Swab samples were collected by using sterile swab at three different places which is at printing shop, library and computer laboratory. Then, the samples were put into the lauryl sulphate broth and were incubated overnight at 37°C. The Mac Conkey agar is used as selective agar to determine the presence of E. coli in keyboard and mouse. **Results:** The E. coli colonies were detected on keyboard and mouse at printing shop, library and computer laboratory. Both keyboard and mouse has highest *E. coli* count with 98.0 cfu/mL and were found at library and printing shop respectively. The lowest E. coli count is 0.0 cfu/mL for keyboard and mouse and it found at all three locations (printing shop, computer laboratory and library). There is significant difference of E. coli contamination between all three places (printing shop, library, computer laboratory). **Conclusion:** The E. coli contamination on keyboard and mouse are really needed to be alarmed regarding to the awareness on cleaning and disinfecting the keyboard and mouse after the operational time. The contamination of E. coli on keyboard and mouse might be due to the poor personal hygiene of user or its surrounding.

Keywords: E. coli, computer; keyboard, mouse, multiple user computer

ABSTRAK

PENENTUAN E. COLI DI PAPAN KEKUNCI DAN TETIKUS DALAM KALANGAN PELAJAR UNIVERSITI

SYAMIM ATHIRA BT MOHD DZUKRI

Pengenalan: Komputer telah menjadi sebagai salah satu alat yang penting dalam pendidikan tinggi. Komputer digunakan secara meluas dalam makmal komputer, kedai percetakan dan perpustakaan untuk akses kepada internet bagi mendapatkan sumber maklumat. Tempat seperti ini kebiasaannya di gunakan oleh orang ramai untuk mengakses komputer. Dengan penggunaan komputer yang semakin meningkat, komputer bertindak sebagai medium penghantaran bakteria patogen seperti E. coli. **Objektif:** Tujuan kajian ini adalah untuk menentukan dan membandingkan pencemaran E. coli di papan kekunci dan tetikus di lokasi yang berbeza (kedai percetakan, makmal komputer dan perpustakaan). **Metodologi:** Sampel swab telah dikumpulkan dengan menggunakan swab steril di tiga tempat yang berbeza iaitu di kedai percetakan, perpustakaan dan makmal komputer. Kemudian, sampel dimasukkan ke dalam Lauryl Sulphate Broth dan dieram semalaman pada 37^{o}C. Mac Conkey agar digunakan untuk menentukan kehadiran E. coli di papan kekunci dan tetikus. **Keputusan:** E. coli dikesan pada papan kekunci dan tetikus di kedai percetakan, perpustakaan dan makmal komputer. Kedua-dua papan kekunci dan tetikus mempunyai bilangan yg tertinggi sebanyak 98.0 cfu / mL di perpustakaan dan juga di kedai percetakan. Bilangan E. coli paling rendah ialah 0.0 cfu / mL untuk papan kekunci dan tetikus di ketiga-tiga lokasi (kedai percetakan, makmal komputer dan perpustakaan). Terdapat perbezaan yang signifikan antara pencemaran E. coli dan ketiga-tiga tempat (kedai percetakan, perpustakaan, makmal komputer). **Kesimpulan**: Pencemaran E. coli pada papan kekunci dan tetikus perlu di di beri kesedaran mengenai pembersihan dan pembasmian papan kekunci dan tetikus selepas masa operasi. Pencemaran E. coli pada papan kekunci dan tetikus mungkin disebabkan oleh tahap kebersihan diri pengguna atau persekitarannya.

Kata kunci: E. coli, papan kekunci, tetikus

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E. coli	*Escherichia coli*

CHAPTER 1

INTRODUCTION

1.1 Study Background

Recently, computer has been an important technological media in almost every single day in individuals' life. The used of the computer has increased among students and also among office staff. In the university environment, students have been used the computers for regular access to internet, and use of email and ordinary word processing. Most university have developed multiple-user computer laboratories for general student access (Mehdinejad et al., 2012). The rate of computer usage and sharing among university students were over 80% to 97% respectively (Ubani & Ofoezie, 2012).

Computer has been on demand as it increasingly presence in almost every aspect of the life. The involvement of hands contaminated with the bacteria such as *E. coli* that may be contributed to the spread of infectious disease has been recognized for many years (Anderson & Palombo, 2009 and Rutala et al., 2006). Plenty of studies have shown that computer keyboards and mice become contaminated with *E. coli.* Moreover, the present study showed that *E. coli* contamination have occurred on keyboard and mouse in a large university environment (Livingstone, 2013).

However, people keep using the computer with hands that constantly contact with other things in the environment without knowing its consequences. As the population of such facility increases, there is need to recognize that computer equipment may act as a reservoir for the transmission of potential hazardous or pathogenic microorganisms (Hartmann et al., 2004). The constant contact with the environment can increased the potential of bacteria and viruses to stick on the keyboard and mouse (Ashgar, 2012).

People who are always eating while working in front of the computer can increase the potential of growing bacteria (Tagoe & Ansah, 2010). Basically, the bacteria will survive for a long time on the wet and soft surface. In humid conditions, bacteria may actively colonize surfaces, transforming a passive reservoir into an active one (Livingstone, 2013).

Another factor that will encourage the growing of bacteria is poor personal hygiene. People usually neglect to wash their hands after going to the bathroom. Besides that, level of the cleanliness of the computer also one of the factor that contribute to the breeding of the bacteria. People seldom clean their computer from dust and other tiny thing that stick at their computer. This situation can make the dust trap moisture which will encourage the bacteria that already on the keyboard to flourish (Elhifnawi, 2009).

According to Ubani & Ofoezie (2012), hygienic practices were uncommon practices among users. Hand washing was observed by only 13.5% of computer users examined in Nigeria. Other unhealthy practices found among computer users included eating (52.1%), drinking (56%), coughing sneezing and scratching of head (48.2%). Based on data from Tagoe & Ansah (2010), all surface of keyboard and mouse were contaminated ($>10^5$) with means of $5.664x10^8$ and $1.305x10^7$ cfu/ml for office keyboard and mouse respectively.

1.2 Problem statement

E. coli are usually present in human host and inanimate object but many people do not realize that *E. coli* can be found in outdoors and other objects that were usually used in daily life. Not many people know that computer component such as keyboard and mouse contain microorganism like *E. coli* which these two items are potential sources for transmitting microorganisms and cross infections. The keyboard and mouse that have been infected with *E. coli* may spread the *E. coli* to other people and make them as a reservoir.

As the students have 100% accessed with high percent of regular internet used and email checking, this will increase the extensive use of computer and students will more often come to the computer laboratory and also to the library to access the internet. Nowadays, the assignments that have given to the students need more information from other sources in the internet. They also have to complete the

assignment by using computer. This situation will make the students often contact with the computer such as keyboard and mouse.

Most of the research related to the microbial contamination of computer keyboard and mouse are done in a university setting, hospital setting and also in cyber café. In these three settings, it involves multiple-users which showed a higher result of contamination in keyboard and mouse (Livingstone, 2013). However, the information and the study towards the *E. coli* contamination in printing shop, computer laboratory and library are rarely done by researcher. Not much people know that *E. coli* in the environment such as in printing shop, computer laboratory and library are developing. The risk and hazard that is posed by this bacteria is not yet fully understood by the computer user (Naeem, 2014).

In Malaysia, there is very limited information about the study of *E. coli* in keyboard and mouse involving university students. Most of the study that related to the bacteria on keyboard and mouse are done in the other country.

1.3 Study justification

This study has shown that the E. coli contamination of multiple user computer keyboards may be a common mechanism for a potentially pathogenic bacteria among users (Naeem, 2014). Computers continue to have an increased presence in almost of every aspect of the occupational, recreational, educations and residential environments (Anderson & Palombo, 2009). The increased availability of multiple

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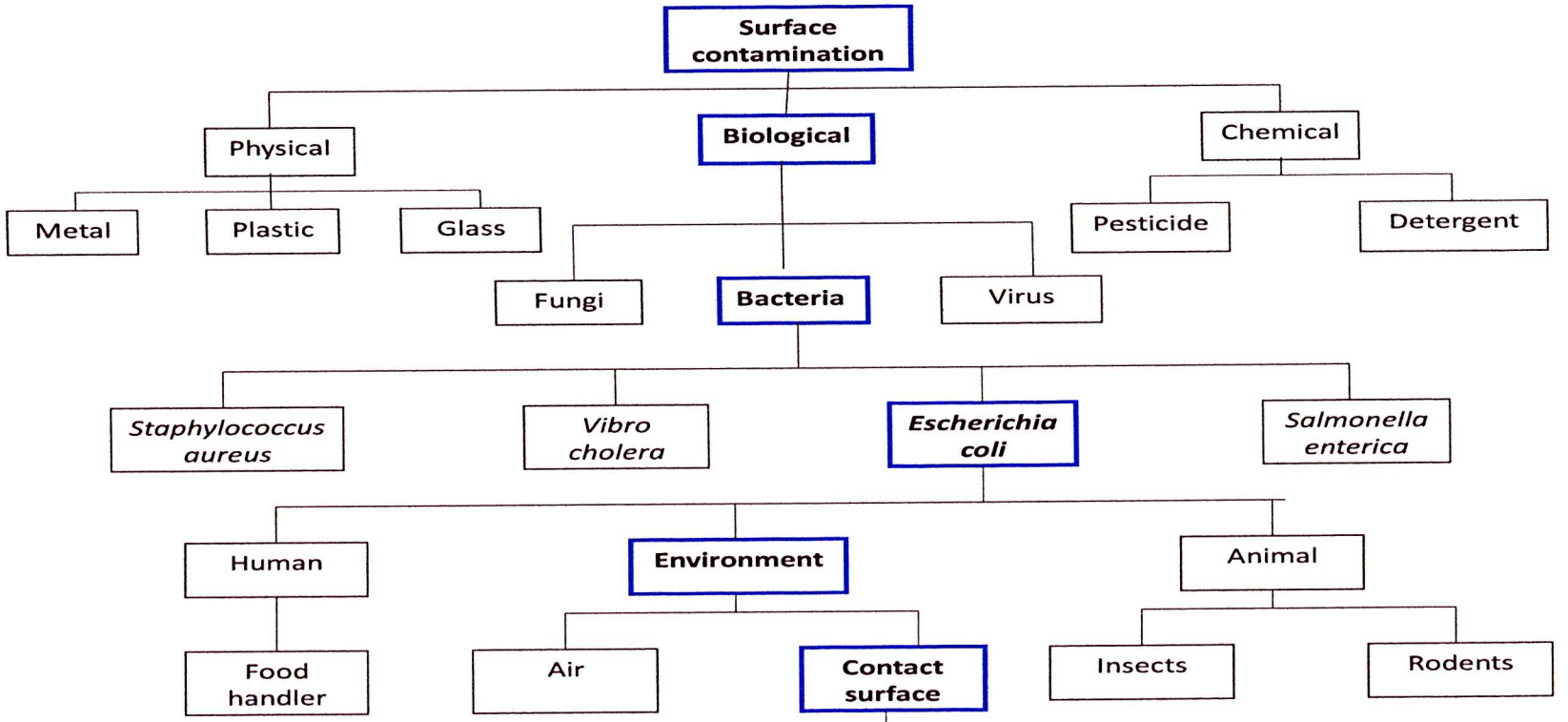
user computer in the university setting means that keyboard and mouse are handled by numerous users on a daily basis.

According to Palmer & Bray (2001), in various university environments, students have indicated 100% access to computers, 92.1% regularly use internet and 73.3% regularly use e-mail. The *E. coli* contamination that occur on keyboard and mouse located in three regions at the university setting (printing shop, library and computer laboratory) which reflect that multiple user environment can be the cause of contamination (Al-mizury, 2015). The study has indicated that the *E. coli* contamination on keyboard and mouse in multiple user may be a typical way of transfer of potentially pathogenic *E. coli* among users (Naeem, 2014).

However, most of the information about the *E. coli* in keyboard and mouse are found from the other country such as Egypt, Ethiopia, Nigeria and Ghana. There is very limited information on study of *E. coli* involving university students in Malaysia.

1.4 Conceptual framework



Dependent variable = Contamination on Keyboard and mouse, Environment

Independent variable = *E. coli*

1.5 Definition of terms

1.5.1 Conceptual definition

- *E. coli*

E. coli is a bacterium which a one-celled organism that is too small to see by the naked eye, and is also sometimes referred to as a microorganism or microbe (Doyle et al., 2011)

- Computer

An electronic machine that is used for storing, organizing and finding words, numbers and pictures for doing calculations and for controlling other machines. (Dictionary Cambridge, 2015).

- Computer Keyboard

A computer keyboard is an input device used to enter characters and functions into the computer system by pressing buttons, or keys. It is the primary device used to enter text. A keyboard typically contains keys for individual letters, numbers and special characters, as well as keys for specific functions (Classwork Series and Exercise (Computer Studies-SS 3) Computer Keyboard, 2015)

- Mouse

A hand-operated electronic device that controls the coordinates of a cursor. An optical mouse has an optical light on the bottom to control the cursor or pointer. A mechanical mouse has a ball on the bottom that rolls to control the cursor or pointer.

- Diarrhea

An abnormal looseness of the stool, changes in stool frequency, consistency, urgency and continence (Surawicz, 2007)

- Urinary Tract Infection

A urinary tract infection (UTI), also known as acute cystitis or bladder infection is an infection that affects part of the urinary tract.

- Blood Stream Infection

Blood stream infection also known as bacteremia is the presence of bacteria in blood stream.

1.5.2 Operational definition

- Computer

Computer is an electronic device which laptop is included in a term of electronic device.

- Keyboard

All keyboards have a layout in English language called QWERTY where the laptop also has the QWERTY key that attached on it. It has similar function as a keyboard in computer.

- Mouse

Touch pad also can be classified as a mouse as it has same function with mouse that have been used in computer.

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1.6 Objectives

1.6.1 General Objective

1. To examine *E. coli* contamination in the keyboard and mouse.

1.6.2 Specific Objective

1. To identify the presence of *E. coli* on keyboard and mouse in three different places (library, printing shop, computer laboratory)
2. To compare *E. coli* contamination on keyboard and mouse at library, printing shop and computer laboratory
3. To compare *E. coli* contamination on keyboard and mouse between three different places (library, printing shop, computer laboratory)

1.7 Hypothesis

1. There is no significant different between *E. coli* contamination on keyboard and mouse in the library, printing shop and computer laboratory
2. There is a significant different of *E. coli* contamination on keyboard and mouse between three different places (library, printing shop, computer laboratory)

CHAPTER 2

LITERATURE REVIEW

2.1 *E. coli (Escherichia coli)*

E. coli is the bacterium that is found in the gut of humans and animals. Most of the *E. coli* are harmless (WHO, 2015). Usually, it exist in good health with human host and also have mutual benefit with them (Kaper et al., 2004). However, several strains of *E. coli* produce toxins that cause illness (Delaware Health and Social Services, 2011). *E. coli* that comprised the serotype *E. coli* 0157:H7 is known to cause serious human illness such as severe diarrhea and kidney damage (Water Stewardship Information Series, 2007; Delaware Health and Social Services, 2011).

The niche of *E. coli* is the mucous layer of mammalian colon. They are highly successful competitor and comprising the most abundant facultative anaerobe of human intestinal. However, there are several highly adapted *E. coli* clones that have an increased ability to adapt to new niches and allows them to cause a broad spectrum of disease (Kaper et al., 2004).

2.2 Health risk

E. coli is pathogenic meaning that *E. coli* can cause illness to human if they are infected with *E. coli* (CDC, 2015). The strain of *E. coli* that causes a disease is called *E. coli* 0157:H7 which they can cause bleeding in the large intestines (Thiel & Ph, 1999). This type of strain produces toxin known as Shiga toxins that may cause severe diarrhea and kidney damage (Delaware Health and Social Services, 2011). Other than that, it also may cause urinary tract infection, respiratory illness and pneumonia (CDC, 2015). The symptoms of *E. coli* usually appear 24 to 72 hours after being infected. Sometimes it can be mild symptoms and sometimes it can be severe depend on the strain of *E. coli* itself (Patient Eduction Institute, 2012).

Usually, people of any age can become infected. However, very young children and very old people are more easily infected with E. coli and more likely to develop severe illness and haemolytic uremic syndrome (CDC, 2015). The symptoms of *E. coli* infections are vary for each person. Basically, the symptom will last within 5 to 10 days (Patient Eduction Institute, 2012).

2.3 *E. coli* in keyboard and mouse

The new development and new technologies that have been provided on several computer applications in recent times make the uses of computer systems have greatly expanded. It becomes important equipment for students and office workers in colleges and offices. However, the frequently used of computer system by multiple

users have been proclaimed that computer system may be the vehicles for transmission of infectious agents (Naeem, 2014). Contamination of keyboard and mouse by *E. coli* with the potential to initiate an infection has been documented by some investigators (Elhifnawi, 2009; Hartmann et al., 2004; Neely & Sittig, 2002).

2.4 Sources of *E. coli*

There are many communities that come into contact with the keyboard. In general, the *E. coli* that lives on the skin, fingernails, hands and anywhere the hands have been are likely to transfer *E. coli* over to the keyboard (Naeem, 2014). Poor personal hygiene is the main source of *E. coli* to become contact with human. Mostly, people do neglect to wash their hand after going to the washroom (Elhifnawi, 2009). Therefore, hands play an important role in *E. coli* transmission and cross contamination on keyboard and mouse (Ubani & Ofoezie, 2012).

Other source of *E. coli* in keyboard and mouse is from the crumbs of the food. Sometimes, students always eat food and at the same time they will use the computer to do their assignments or watching movies. The crumbs of the food will spills between the keys which it will encourage the growth of *E. coli* (Elhifnawi, 2009).

The capability of the bacteria to survive for more than 24 hours further increases their chances of contamination in other places. The environmental conditions vary depending on the temperature around the keyboard and whether or not the keyboard is on a laptop. If the keyboard is on a laptop it could possibly provide heat and moisture for long enough durations to have an effect on *E.coli* which is known to survive wide range of environmental condition (Naeem, 2014).

2.5 Studies done involving *E. coli* in world

Based on the Table 2.3, *E. coli* in keyboard in Nigeria is higher than *E. coli* in keyboard in Ethopia because the keyboard in Nigeria was likely facilitated the colonization via hand-to-mouth or hand-to-nose contact while using the keyboard and also poor hand-washing habits (ASM, 2005). The percentage of *E. coli* contamination in mouse is higher in Ethopia because the computer was used by multiple-user which the possibility of their palm contains more *E. coli* compared to their finger is higher.

In Ghana, the percentage of *E. coli* is higher in keyboard because of the number of user that comes to use the computer. The sample was taken at the cyber café which the keyboard in the internet café were more contaminated as they also selling and eating the food while using computer (Tagoe and Kumi-Ansah, 2011). The foods that wind up on and between the keyboards will be the perfect place for *E. coli* to growth (Eltablawy and Elhifnawi, 2009).

Table 2.3: Past studies related with *E. coli* involving keyboard and mouse

Researcher/ Year/ Location	*E. coli* in keyboard (%)	*E. coli* in mouse (%)
Nwankiti et al. (2012), Nigeria	20.0	16
Agersew et al. (2015), Ethopia	3.6	17.3
Tagoe and Kumi-Ansah, 2011, Ghana	2.86	0.0

CHAPTER 3

METHODOLOGY

3.1 Study design

A cross sectional study was conducted as it was conducted over a short period of time from February until April 2016 at Faculty of Medicine and Health Sciences.

3.2 Study location

This cross sectional study was conducted at Faculty of Medicine and Health Sciences, University Putra Malaysia, Selangor. There were three places involved and the places are printing shop, computer laboratory and library. These three places were chosen as they involve multiple user computer among students in that faculty. According to Livingstone (2013), multiple users computer are more vulnerable to had significantly more numbers of *E. coli* compared to single user computer as it used by predominantly one person

3.3 Sampling

3.3.1 Sample

Swab samples were taken from the keyboard and mouse at the Faculty of Medicine and Health Sciences

3.3.2 Sampling method

Sampling method that has been used in this study is purposive sampling. The samples were collected based on the inclusive and exclusive criteria.

Inclusive criteria:-

i) The used of keyboard and mouse must be shared by all students (multiple user)

ii) The keyboard and mouse should be located at the printing shop, library and computer laboratory as it is the location for this study and it involves sharing of the computer (multiple user computer).

Exclusive criteria:-

i) Personal computer that is used by the students as it does not involve single user computer

ii) Computer that is used by staff at Faculty of Medicine and Health Sciences as it only involves university students.

3.3.3 Data collection

Sample of *E. coli* was using sterile swab and the sterile swab was wiped on the keyboard and mouse. A total of 120 swabs were collected which 60 swab samples from keyboard and another 60 samples were from mouse. At the printing shop, the total keyboard and mouse sampled was 13 of each. For the computer laboratory, the total sample for keyboard and mouse is 29 sample of each and at the library is 18 sample of each keyboard and mouse. The swab samples of *E. coli* should be collected at least 12 hours after the laboratories were last occupied by students (Anderson & Palombo, 2009).

Figure 3.1: Sterile swabs

Figure 3.2: Computer laboratory

3.4 Instrumentation

The temperature and relative humidity were measured by using Q-Trak. After the *E. coli* sampling, the reading of the temperature and relative humidity were taken as the factors that can contribute to the growth of *E. coli*.

Figure 3.3 :Q-Trak

3.5 Analysis of *E. coli*

In this study, determination of *E. coli* in keyboard and mouse was determined by method done by Naeem, (2014). The method is using sterile swab to collect the samples from keyboard and mouse. The *E. coli* was determined by using selective agar which is Mac Conkey agar. The light pink colour colonies were observed which confirmed the presence of *E. coli* in the culture. The process of *E. coli* determination in keyboard and mouse are as follows:-

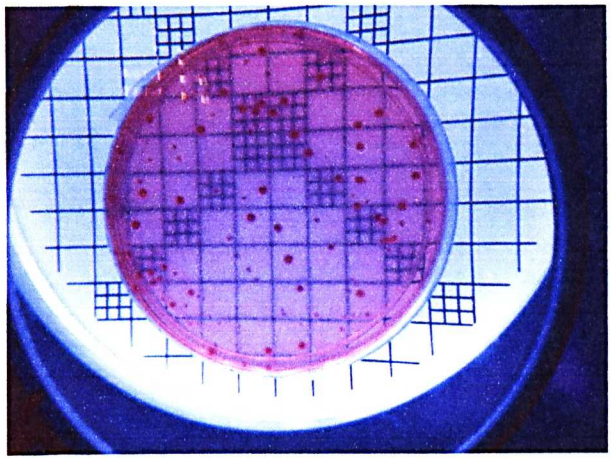

Figure 3.4*: E. coli* colonies on Mac Conkey agar

Figure 3.5: *E. coli* samples from keyboard and mouse

A sterile swab was moistened with sterile saline solution and will wipe the surface of keyboard and mouse.

Each swab was placed in 20 ml of Lauryl Sulphate broth (LSB) in a small bottle and vortexed for one minute.

All the samples were dipped separately into Lauryl Sulphate broth (LSB) and left in the shaker overnight at 25 °C. and 250 rpm.

After 18-24 hours, small amount of sample was taken and cultured on the Mac Conkey agar

The cultured samples then were left on the incubator overnight with the temperature of 37 °C to determine the presence of *E. coli*.

Figure 3.5: *E. coli* samples after incubated overnight

A sterile swab was moistened with sterile saline solution and will wipe the surface of keyboard and mouse.

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Figure 3.5: *E. coli* samples after incubated overnight

For the analysis of *E. coli*, the first step is the sterile swab was moistened with sterile saline solution and was wiped on the surface of keyboard and mouse. Then, each of the swab was placed in 20 ml of Lauryl Sulphate broth in a small bottle and vortex for one minute. After that, all the samples were dipped separately into Lauryl Sulphate broth and left in the shaker overnight at at 25 °C. and 250 rpm. After 18-24 hours, small amount of sample was taken and cultured on Mac Conkey agar and left the sample in the incubator overnight with the temperature of 37 °C to determine the presence of *E. coli*. The method is using sterile swab to collect the samples from keyboard and mouse. The *E. coli* was determined by using selective agar which is Sorbitol Mac Conkey agar. The light pink colour colonies were observed which confirmed the presence of *E. coli* in the culture.

3.6 Quality control

- All the petri dishes were steriled with the dettol before put the agar inside the petri dish to avoid contamination during analysis.
- Each of the samples performs triplicates analysis to ensure the validity of result.
- All the apparatus such as bottle were autoclaved at 121°C for 15 minutes before use.
- The sample was analysed as soon as possible after the sample had been collected.
- The table had been disinfected with 65% of alcohol before culture the E. coli.

3.7 Data analysis

Data analysis was done by using Statistical Package for Social Sciences (SPSS) Version 22.0. The normality data of *E. coli* on keyboard and mouse in three different places which is library, computer laboratory and printing shop is not normally distributed as the p value is less than 0.05. For the comparison of *E. coli* contamination on keyboard and mouse, it is determined by using Mann U Whitney test. The Kruskal Wallis test also is used to understand the significance between *E. coli* in keyboard and mouse in three different places (library, computer laboratory and printing shop).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Descriptive statistic of *E. coli* contamination on keyboard and mouse

Table 4.1 shows the *E. coli* colonies in keyboard and mouse ranging between 0.0 cfu/mL to 98.0 cfu/mL. The highest *E. coli* count was at library with 98.0 cfu/mL while the lowest count of *E. coli* colonies (0.0 cfu/mL) found at all three places (library, computer laboratory and printing shop). The *E. coli* colonies of mouse ranged between 0.0 cfu/mL and 98.0 cfu/mL. Printing shop has the highest count of *E. coli* colonies with 98.0 cfu/mL while these three locations (printing shop, computer laboratory and library) have the lowest *E. coli* colony (0.0 cfu/mL).

At the printing shop, the total keyboard and mouse sampled was 13 of each and the contamination of *E. coli* on keyboard and mouse was 84.6% and 100% respectively. For the computer laboratory, the total sample for keyboard and mouse is 29 sample of each and mouse shows the higher contamination of *E. coli* with 79.3% and keyboard with 44.8%. At the library, it also shows that mouse has higher contamination of *E. coli* compared to keyboard with 61.1% and 38.9% respectively.

Table 4.1: *E. coli* colonies (cful/mL) on keyboard and mouse at library, printing shop, computer laboratory

	Library (cfu/mL)	Printing shop(cfu/mL)	Computer laboratory (cfu/mL)
Keyboard			
Median	0	16	0
Min	0	0	0
Max	98	94	91
Range	98	94	91
Mouse			
Median	0.5	45	5
Min	0	0	0
Max	92	98	96
Range	92	98	96
N=60		*(Statistical Test: Descriptive Test)*	

4.2 *E. coli* contamination on keyboard and mouse at different locations

The Table 4.2 and 4.3 showed the comparison of *E. coli* between keyboard and mouse at different location. The locations played an important role of *E. coli* contamination on keyboard and mouse. There is a significant difference of *E. coli* contamination on both keyboard and mouse as the $p<0.05$ at all three places (printing shop, library, computer laboratory). The mean rank of the keyboard at library is 81.30 while at printing shop is 120.97 and 82.55 at the computer library. The close

mean rank at the library and computer laboratory indicates that the result of the *E. coli* contamination had equal level and both of these places also have close mean rank of mouse.

Table 4.2: Comparison between *E. coli* contamination on keyboard at different locations (library, printing shop and computer laboratory)

Locations	Keyboard			
	Median	Mean rank	X^2	p
Library	0.00	81.30		
Printing shop	16.00	120.97	20.843	<0.01
Computer laboratory	0.00	82.55		

Kruskal Wallis test * significant at p<0.05

Table 4.3: Comparison between *E. coli* contamination on mouse at different locations (library, printing shop and computer laboratory)

Locations	Mouse			
	Median	Mean rank	X^2	p
Library	5.00	72.40		
Printing shop	45.00	123.06	23.013	<0.01
Computer laboratory	5.00	87.14		

**p - value significant < 0.05 level (Statistical Test: Kruskal-Wallis Test)*

4.3 Factors *E. coli* contamination on keyboard and mouse at different locations

It can be seen that locations influenced the *E. coli* contamination on keyboard and mouse. *E. coli* can survive well in environment and grow alone. Basically there are a few factors that contribute in the growth of *E. coli*. The two basic factors are temperature and relative humidity. There is a range of temperature where the *E. coli* can survive and grow which is 28 °C-45 °C. The best temperature for the *E. coli* to survive is 37°C with the available of nutrients and moisture (Nguyen, 2006). However, the number of *E. coli* may decreased at the higher temperature and corresponding lower humidity (Milling et al., 2005). Based on the study, the printing shop had a temperature of 27.5 °C while computer laboratory had a temperature of 25.7°C and library had temperature of 24.1°C. The E. coli can survive long time in a low temperature compared to higher temperature (Doyle, 2008). For the humidity, printing shop had 47.7%, computer laboratory had 63.3% and library had 62.6%. All these temperature and relative humidity were taken after the E. coli sampling. The temperature plays influential factor on growth of *E. coli* than the ambient relative humidity changes (Wang et al., 2012).

Other than that, the lighting also will affect the grow of the *E. coli*. The exposure to light, results in different effects depending on wavelength, intensity and the type of test light (Djurdjevic-Milosevic et al., 2003). *E. coli* has shown the effect of motility on the exposure to intense light in the region between 390 and 530 nm. The minimum intensities of white light (1.9 J/cm2/s) produced tumbling response in *E. coli* (Taylor & Koshland Jr., 1975). However, the light above 400nm strongly inhibited the process of respiration and enzyme activities of *E. coli* (D'Aoust et al., 1974). At the computer laboratory, printing shop and library, the lighting is quite

dimmed and it does not use the white light. Moreover, the lighting is not on for 24 hours and will be switched off when the place is not being used. This situation will give chance to *E. coli* to grow.

The factors that affect the *E. coli* contamination on keyboard and mouse at computer laboratory are less awareness of performing hand hygiene and also the mouse and keyboard are not disinfected. These two reasons could be the sources of *E. coli* transmission to the keyboard and mouse (Siegmund et al., 2010). Hands may have pathogenic organisms such as *E. coli* that may cause contamination of high-touch areas such as computer keyboards (Srikanth et al., 2012). Other than that, rarely cleaning the keyboard and mouse could enhance the dust to trap between the keys on keyboard and mouse which enable the *E. coli* to flourish (Elhifnawi, 2009)

CHAPTER 5

CONCLUSION

5.1 Conclusion

Computer has an important role in student education. This study found *E. coli* contamination on keyboard and mouse at printing shop, computer laboratory and library. It has shown that library has the highest *E. coli* colonies with 98 cfu/mL on keyboard and the lowest colonies were 0 cfu/mL found in all three locations (printing shop, library and computer laboratory). *E. coli* on mouse shows that the highest *E. coli* contamination was at printing shop with 98 cfu/mL. In all three places, it shows that mouse has higher contamination of *E. coli* compared to keyboard. Kruskal Wallis study showed that the *E. coli* in mouse and keyboard are different with each another due to several factors such as temperature, humidity, lighting and hygiene practice. Since the keyboard and mouse are providing a surface for colonisation, the user and should be aware about their hygiene.

5.2 Recommendations

To avoid the bacteria such as *E. coli* to spread and cause a health problem to human body, the appropriate surface disinfection should be done in all keyboard and mouse regularly. The awareness of cleaning of the computer surface or disinfections should be addressed by the user and owner or guardian of the place. However, different people might have different hygienic status. Hence, adequate hand hygiene is important to avoid from getting attached with bacteria such as *E. coli.* Since this study has showed that computer keyboard and mouse are contaminated, hand washing hygiene practice is necessary to be conducted before and after using the computer to reduce the risk of contamination and cross contamination.

5.3 Study limitations

The limitation of this study is that the data of this study is based on the keyboard and mouse only. There is no external information such as questionnaire to support the data. Other than that, the data presented is based on one time sampling. To determine the persistence of the *E. coli* on keyboard and mouse over time, simultaneous sampling of hands also should be carried out. Besides that, the only bacteria that is investigated in this study is *E. coli.* Other bacteria such as *Staphylococcus aureus, Bacillus subtilis, Salmonella* sp and *Streptococcus* sp might be harbour on the keyboard and mouse also.

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Prof Dr Zamberi Sekawi

b) Date of approval: 29/1/2016

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Samples of E. coli at printing shop

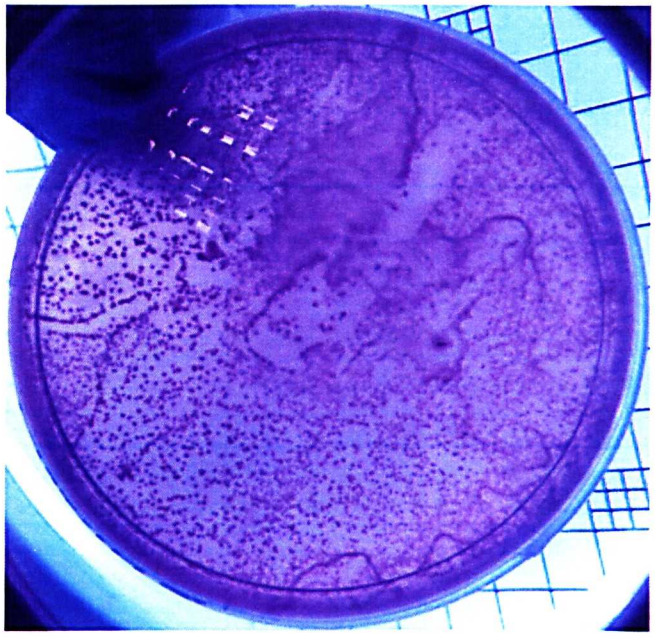

Figure 1: E. coli on keyboard 1

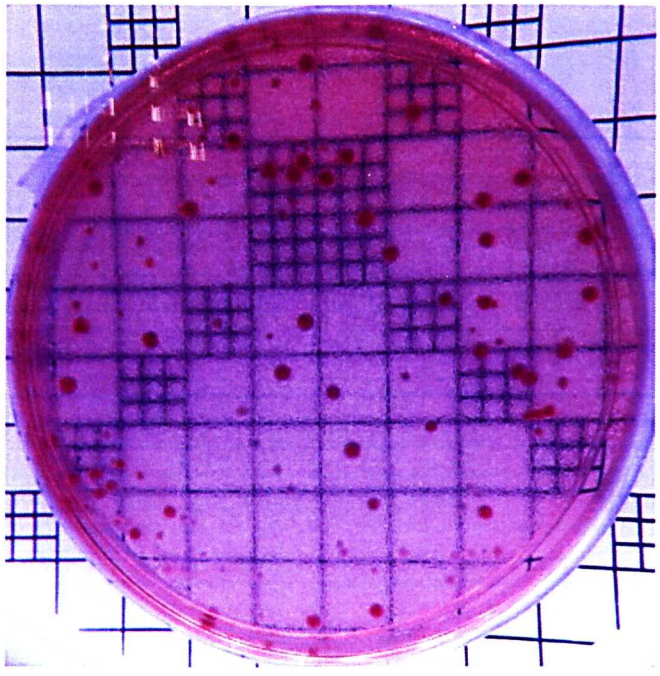

Figure 2: E. coli on mouse 1

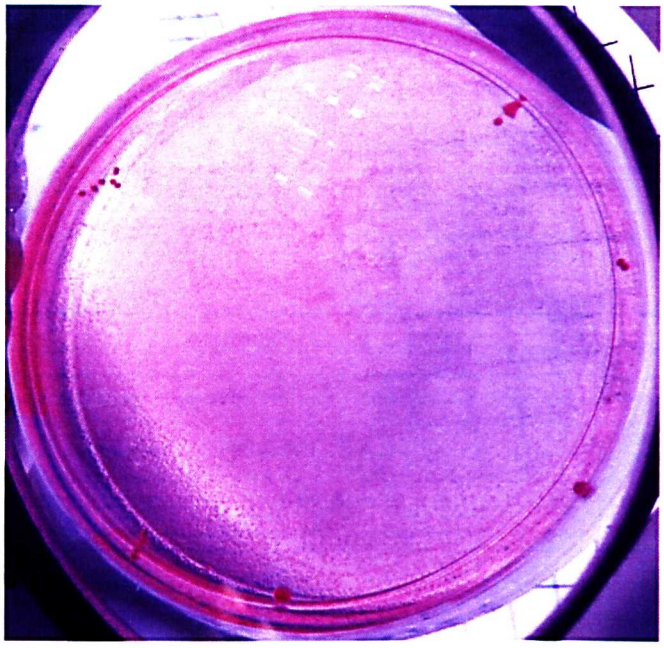

Figure 3: E. coli on keyboard 2

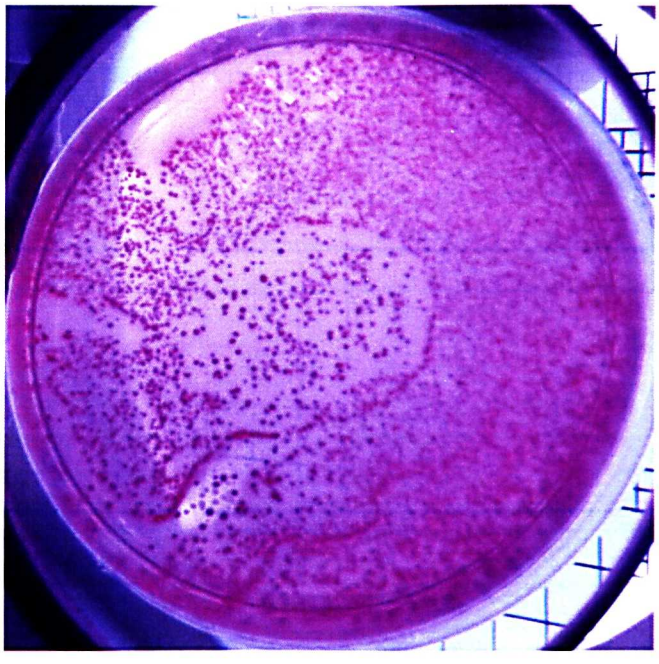

Figure 4: E. coli on mouse 2

Samples of E. coli at library

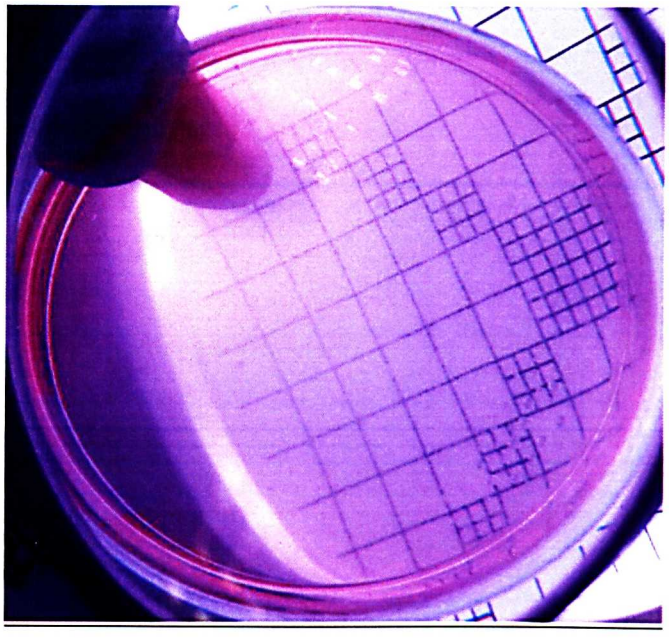

Figure 1: Sample on keyboard 1

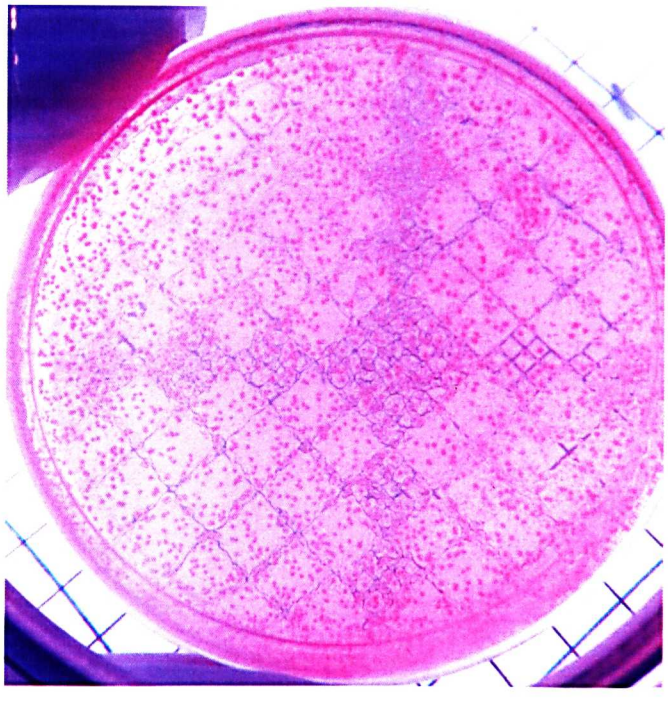

Figure 2: E. coli on mouse 1

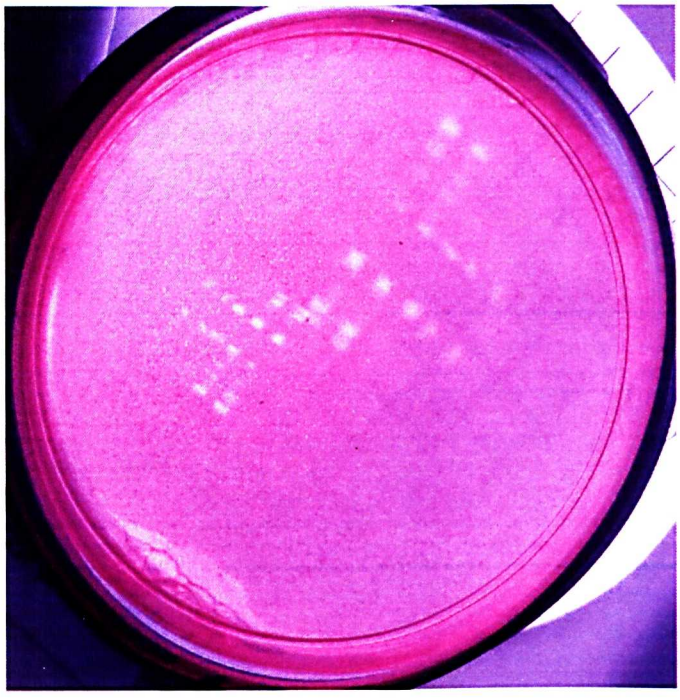

Figure 3: E. coli on keyboard 2

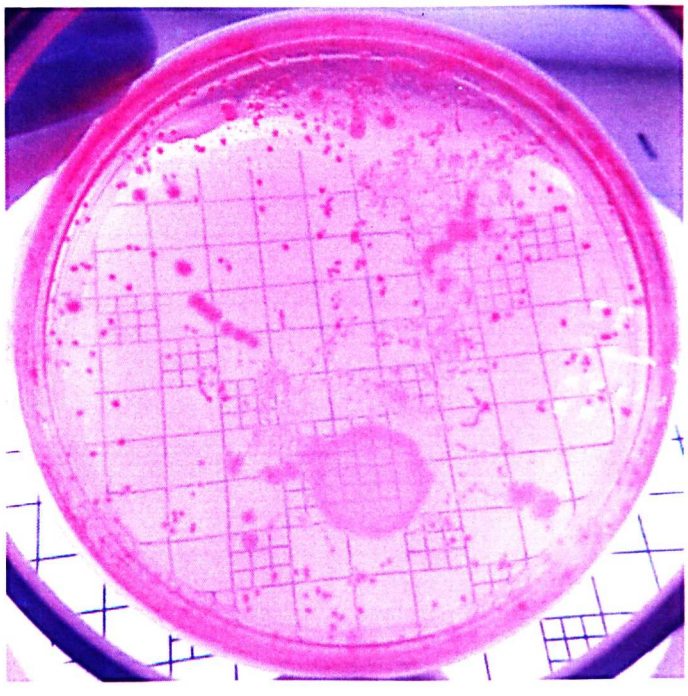

Figure 4: E. coli on mouse 2

Samples of E. coli at computer laboratory

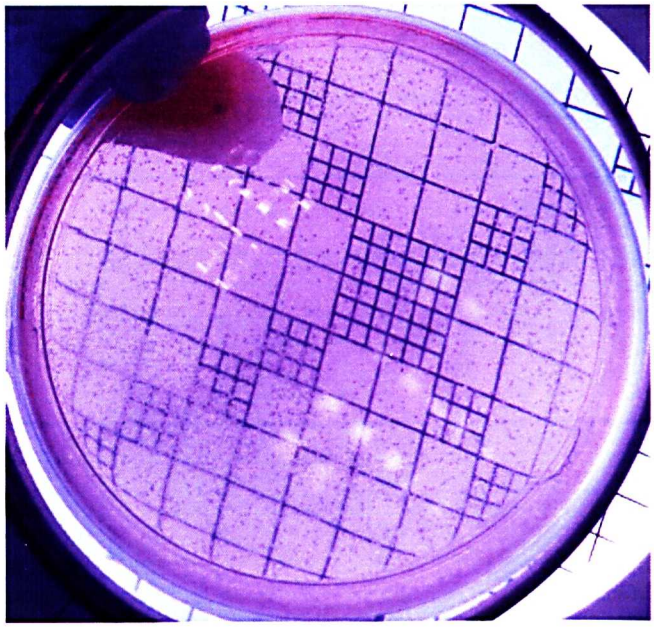

Figure 1: E. coli on keyboard 1

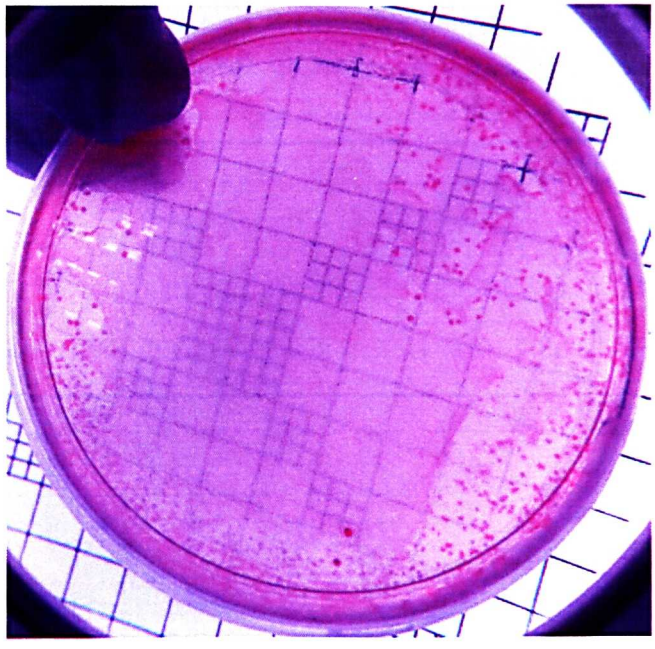

Figure 2: E. coli on mouse 1

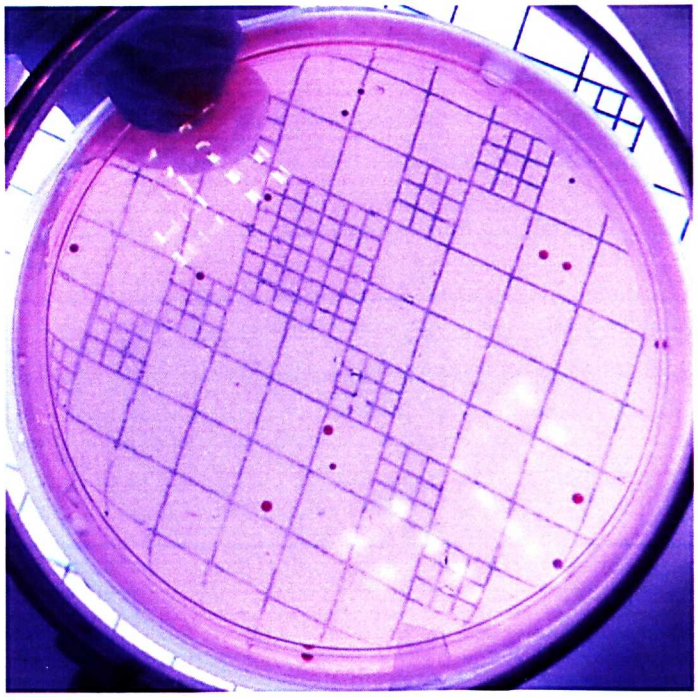

Figure 3: E. coli on keyboard 2

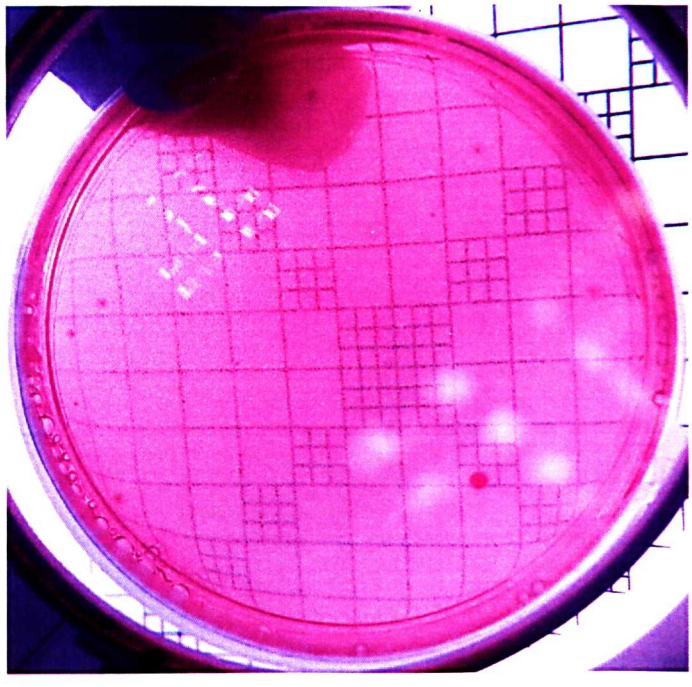

Figure 4: E. coli on mouse 2