

Microbiological Contamination Model of Staff Hands Employed at Bakeries Due to Staff's Life Style and Individual Parameters ^[1]

Emek DUMEN *  Funda SEZGIN **

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* Istanbul University, School of Veterinary Medicine, Department of Food Hygiene and Technology, 34320 Avcılar, İstanbul - TURKEY

** Mimar Sinan Fine Arts University, Faculty of Science and Letter, Department of Statistics, 34349 Beşiktaş, İstanbul - TURKEY

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Summary

In this study it is aimed how to determine correlations between gender, marital status, child status, hometown, education and position in the sales point variables of the bakery staff, employed in 5 different geographic regions of in Turkey at 100 franchise bakery shops belong same brand, effect the microbiological load of their hands by forming a microbiological contamination model using the statistical methods. We chose 30 sales points from Marmara region, 60 sales points from Aegean, Middle Anatolian and Mediterreanean regions, 20 sales points for each region, and 10 sales points for Black Sea regions. During 12 months 3 staff were has been chosen from each sales point and for the total time interval of the study the same staff were sampled except the conditions which are not due to study team as job quitting, illness problems, vacations and so on. The swab samples were analyzed in the point of view of counts of total aerobic mesophiles coliforms, *Escherichia coli* and *Staphylococcus aureus*. For establishing a microbiological contamination model due to how staff's individual and life style parameters effect the microbiological load of their hands all the parameters and variables were subjected to comparative logistic regression analysis. For all the geographical regions, the education and the marital status of the staff were determined as statistically important variables that affect the microbiological load of the staff hands which can risk consumers' health.

Keywords: *Microbiological modeling, Bakery, Staff*

Pastanelerde İstihdam Edilen Personelin Ellerin Mikrobiyolojik Yükünün Kişisel ve Yaşam Biçimleri Özelliklerine Göre Modellenmesi

Özet

Bu çalışmada, Türkiye'nin beş değişik coğrafi bölgesinde bulunan ve aynı marka adı altında faaliyet gösteren toplam 100 adet satış noktasında istihdam edilen personelin cinsiyet, yaş, medeni durum, çocuk durumu, memleket kökeni, eğitim durum ve işletmedeki pozisyonunun, personelin ellerindeki mikrobiyolojik yükü nasıl etkilediğinin modellenmesi amaçlanmıştır. Toplam 100 adet satış noktasından 30 adedi Marmara bölgesinden, 20'şer adedi Ege, Akdeniz ve İç Anadolu bölgelerinden, 10 adedi ise Karadeniz bölgesinden seçilmiştir. Her satış noktasında yıl boyunca, işten ayrılma durumu hariç, aynı personel üzerinde çalışılmış ve her bir nokta için 3 adet değişik pozisyonlardaki personel seçilmiştir. Personelden alınan el sürüntüleri toplam mezofilik aerobik bakteri, toplam koliform grubu bakteri, *Escherichia coli* ve *Staphylococcus aureus* parametreleri yönünden analize alınmıştır. Personelin bireysel değişkenlerinin ellerindeki mikrobiyolojik yükü nasıl etkilediğinin modellenmesi için, tüm parametreler karşılaştırmalı lojistik regresyon analizine tabi tutulmuştur. Tüm bölgeler için, personelin eğitim ve medeni durumu, tüm mikrobiyolojik parametreler açısından mikrobiyolojik kirlilik üzerine etkili olan ve istatistiki olarak önemli bireysel değişkenler olarak tespit edilmiştir.

Anahtar sözcükler: *Mikrobiyolojik modelleme, Pastane, Personel*

INTRODUCTION

Food borne diseases (FBD), in particular gastro-intestinal infections, represent a very large group of pathologies with a strong negative impact on the

health of the population because of their widespread nature ¹⁻⁵. Foods that are frequently associated with Staphylococcal and *Escherichia coli* food poisoning



İletişim (Correspondence)



+90 212 4737070/17154



emekdumen@yahoo.com

include meat, salads, sandwich accoutrements, and especially cream-filled bakery items dairy products⁶⁻⁸.

The risk of food-borne illness due to contact with hands or surfaces depends on both the level of contamination as well as the probability of transfer and the importance of contaminated surfaces in relation to potential transmission of pathogens to food is apparent in food processing⁹⁻¹⁵.

According to the laws related to the new hygiene regulations of European Community (EU), it is a compulsory process for all kinds of food plants to apply food security systems at the all steps of the production and selling processes since 2005/2006¹⁶⁻²².

Coliforms and *E. coli* are the main indicator micro-organism groups that determine fecal contamination and inadequate hygienic status of the foods²³⁻³³. The most important contamination source of the mentioned microorganism groups are the toilets that have inadequate hygienic status and the staff who do not apply hygiene processes especially after using the toilets.

Staphylococcus aureus, is the main third strain cause to food poisoning in the world³⁴⁻³⁶. The toxins of *S. aureus* are thermo stabile molecules. Even the agent is inactivated; there may be a high possibility of contamination of the toxins to the food mechanically and also to the consumers, too, if the agent had enough time for producing enterotoxins³⁷.

In this study, it is aimed to explore if gender, age, marital status, child status, hometown, education level and the position in the plant variables effect the microbiological load of the hands of staff employed at bakeries were explored by forming a statistical microbiological contamination model due to the parameters mentioned above. We also aimed to indicate which variable(s) plays predisposition role or facilitate to increase microbiological loads of the hands for *E. coli*, coliforms bacteria count, *S. aureus* and counts of total aerobic mesophiles parameters. So, we explored the relation between staff's individual variables and microbiological load of their hands by forming a statistical contamination model.

MATERIAL and METHODS

Material

We used hand swabs of staff employed at the visited bakeries located in different regions and cities of Turkey as material in this study.

Methods

Swab Sampling from hands: Study team visited a total of 100 bakeries belonged to same brand located in 5 different geographical regions of Turkey (Marmara, Aegean, Mediterranean, Black Sea and Middle Anatolian) every month during the year 2006. We chose 30 sales points from Marmara region, 20 sales points from Aegean region, 20 sales points from Mediterranean region, 20 sales points from Middle Anatolian region and 10 sales points from Black Sea region as total of 100 sales points. We sampled 3 staff from each sales point and we tried to sample the same staff except special conditions that are not due to the study team as job quitting, illness problems and off days of the staff. The hand swab samples were analyzed for 4 microbiological parameters as counts of total aerobic mesophiles, coliforms, *E. coli* and *S. aureus*. During the study, team members were also responsible from recording the individual data of the staff whose hand swab samples were taken (gender, age, marital status, child status, hometown, educational status and the position in the plant were the data that are recorded). According to the individual data of the staff, we formed microbiologic contamination models to expose if the lifestyle and social status of the staff of the food plants affect the public health and the food security directly or indirectly.

Microbiological Analysis: At the end of every sampling process, we transported the samples to laboratory immediately and the related analyses were made in the same day. All the samples taken from staff were analyzed according to the FDA-BAM norms for counts of total aerobic mesophiles, coliforms, *E. coli* and *S. aureus*³⁸.

Logistic Regression Analysis: The relationship between each microbiological parameters (counts of total aerobic mesophiles, coliforms, *Escherichia coli* and *Staphylococcus aureus*) and the individual variables of the staff were analyzed was to expose if the microbiological parameters are the indicator of the individual variables or not. Acceptable and non-acceptable parameters were enumerated with 0 and 1 codes respectively. Forward Wald method was used for each single micro-biological parameter for logistic regression analysis at SPSS version 10.0.

RESULTS

According to our results, microbiological contamination level of staff from different geographic

regions were significantly different from each other ($P < 0.05$). *Table 1* shows the results of the differences among geographical regions of the microbiological contamination level of the staff. One way variance analysis method (MANOVA) was used to form the model of contamination according to the geographical regions parameter. One way variance analysis indicates the statistically significance differences two or above variables for a single parameter ³⁹.

Logistic regression analysis method was used to form the microbiological contamination model according to the chosen parameters for the staff's individual variables. For the counts of total aerobic mesophiles

parameter, education variable of the analyzed staff was effective. Education level was inversely proportional with the contamination level of the indicated parameter. *Table 2* shows the logistic regression analyses results for counts of total aerobic mesophiles parameter. The marital status and education variables of the staff were designative for coliforms parameter. Married staff was cleaner than divorced and single staff. *Table 3* shows the logistic regression analysis results for coliforms parameter. Parallel to coliforms parameter, the marital status and the education variables again were the effective variables for *E. coli* and *S. aureus*. *Table 4* and *Table 5* show the logistic regression analysis results for *E. coli* and *S. aureus* parameters respectively.

Table 1. MANOVA results of the differences among the geographic regions of the microbiological pollution level of staff

Tablo 1. Personel ellerindeki mikrobiyolojik kirlilik seviyesinin coğrafi bölgelere göre farklılıklarının MANOVA sonuçları

Variables	Effect	Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.000	150895.8 ^a	9.000	47.000	.000*
	Wilks' Lambda	.000	150895.8 ^a	9.000	47.000	.000*
	Hotelling's Trace	28894.936	150895.8 ^a	9.000	47.000	.000*
	Roy's Largest Root	28894.936	150895.8 ^a	9.000	47.000	.000*
Region	Pillai's Trace	2.025	5.699	36.000	200.000	.000*
	Wilks' Lambda	.000	54.809	36.000	177.868	.000*
	Hotelling's Trace	2882.839	3643.588	36.000	182.000	.000*
	Roy's Largest Root	2880.918	16005.099 ^b	9.000	50.000	.000*

a: Exact statistics b: The statistic is an upper bound on F that yields a lower bound on the significance level.

$\alpha = 0.05$ significant level, statistical differences among the geographical regions was determined because $P < 0.05$

Table 2. Logistic regression analyses results for counts of total aerobic mesophiles parameter

Tablo 2. Toplam mezofilik aerobik bakteri sayısı parametresi için lojistik regresyon analizi

Variables	B	S.E.	Wald	df	Sig.	Exp (B)
Sex	.464	.456	1.035	1	.309	1.590
Age	-.171	.312	.300	1	.584	.843
Marrital Status	.873	.484	3.245	1	.072	2.393
Child Status	.120	.596	.041	1	.840	1.128
Hometown	-.145	.146	.990	1	.320	.865
Education	1.573	.363	18.824	1	.000*	4.820
Position in the Plant	-.037	.289	.017	1	.898	1.038
Constant	-6.123	1.262	23.526	1	.000	.002

$\alpha = 0.05$ "*" signed parameters are significant statistically at 0.05 level

For the goodness of fit λ^2 was used. Model is significant with $\lambda^2 = 97.1$ $P = 0.032$

Table 3. Logistic regression analysis results for coliforms parameter

Tablo 3. Toplam koliform grubu bakteri sayısı parametresi için lojistik regresyon analizi

Variables	B	S.E.	Wald	df	Sig.	Exp (B)
Sex	.267	.340	.614	1	.433	1.305
Age	.149	.230	.422	1	.516	1.161
Marrital Status	1.419	.413	11.806	1	.001*	4.135
Child Status	.632	.539	1.373	1	.241	1.881
Hometown	-.236	.109	4.654	1	.031*	.790
Education	1.646	.242	46.280	1	.000*	5.188
Position in the Plant	-.205	.252	.670	1	.413	.815
Constant	-4.918	1.030	22.805	1	.000	.007

$\alpha = 0.5$ "*" signed parameters are significant statistically at 0.05 level

For the goodness of fit λ^2 was used. Model is significant with $\lambda^2 = 56.3$ $P = 0.2$

Table 4. Logistic regression analysis results for *E. coli*
Tablo 4. *E. coli* için lojistik regresyon analizi

Variables	B	S.E.	Wald	df	Sig.	Exp (B)
Sex	.206	.337	.376	1	.540	1.229
Age	.244	.222	1.205	1	.272	1.276
Marrital Status	1.529	.407	14.099	1	.000*	4.616
Child Status	.589	.533	1.224	1	.269	1.803
Hometown	-1.25	.107	1.357	1	.244	.883
Education	1.691	.234	52.414	1	.000*	5.423
Position in the Plant	-.356	.253	1.987	1	.159	.700
Constant	-4.929	1.009	23.882	1	.000	.007

$\alpha = 0.5$ "*" signed parameters are significant statistically at 0.05 level
 For the goodness of fit λ^2 was used. Model is significant with $\lambda^2 = 41$. P=0.0

Table 5. Logistic regression analysis results for *S. aureus*
Tablo 5. *S. aureus* için lojistik regresyon analizi

Variables	B	S.E.	Wald	df	Sig.	Exp (B)
Sex	.264	.326	.656	1	.418	1.302
Age	.170	.219	.605	1	.437	1.185
Marrital Status	.734	.354	4.295	1	.038*	2.084
Child Status	.125	.466	.071	1	.789	1.133
Hometown	-.066	.104	.406	1	.524	.936
Education	1.290	.227	32.172	1	.000*	3.634
Position in the Plant	-.028	.225	.015	1	.902	.973
Constant	-4.117	.911	20.446	1	.000	.016

$\alpha = 0.5$ "*" signed parameters are significant statistically at 0.05 level
 For the goodness of fit λ^2 was used. Model is significant with $\lambda^2 = 87$. P=0.37

DISCUSSION

According to our results, significant differences determined among all the geographical regions at P<0.05 level in spite of all visited bakeries were the franchise of the same brand (data not shown). We think that this is because there are not homogenous employment conditions in the visited sales points and inadequate education applications. The marital status, hometown and education positions of the staff were highly variable even at the same sales point. We can also say that staff hygiene, consequently the product hygiene and the consumers' health is directly related with the education. In a study, Bas et al.⁴⁰ made an investigation at 115 food plants and pointed out that, critical control points of the food plants vary according to the demographic structure and regional differences. In our results, too, demographic structure is the factor that determines the differences among the geographical regions. We also think that various traditions that change due to geographic regions (crowded family, culture, dominant work sectors in some regions, etc.) form the microbiological contamination differences of the staff hands among the geographical regions basically.

The education variable was statistically significant in our model for counts of total aerobic mesophiles parameter at P<0.05 level. Other individual variables were not statistically significant due to our results. According to the odds ratio values in Exp (B) column, education variable for counts of total aerobic mesophiles parameter is 5 times effective on microbiological contamination of the staff hands for our microbiological model. In the classification table, dirty decided staff were estimated at a rate of 93.3% and clean decided staff were estimated at a rate of 94.9%. All the microbiological paramters' appropriateness evaluation was decided according to the criterion of floury food products stated in Turkish Codex Alimentarius⁴¹, Codex Alimantarius¹⁷ and FDA-BAM^{38,42}. Centers for Disease Control and Prevention⁴³ reports that hands including the enteric viruses, are the main contamination sources of the food borne diseases⁴⁴. We also want to state that the hands are also the most important contamination way of hepatitis A virus outbreaks in spite of mentioned parameter was not investigated in our study⁴³. We directly relate hand washing habit to education levels of the staff. Appropriate hand washing processes eliminate soil sourced pathogens⁴⁵. It is very important to use the right chemicals (non-

toxic to foods, must not leave any residues on the hands, must provide antiseptics condition) while washing hands as for proper washing habit⁴⁶⁻⁴⁸. It is pretty hard to remove the permanent microorganisms from hands by friction movements because they are protected by the glands that secrete fats^{49,50}. In this respect, even to wash hands frequently may not be effective for eliminating soil sourced pathogens if the right chemical agents are not used. We think that high educated staff would increase the effectiveness of the hygiene applications and food security systems. According to the results we got, while the microbiological pollution model of the staff hands was being formed at the 2nd step of the study, 86.3% of 300 staff (259 staff, data not shown) had values above 103 cfu/10 cm² for counts of total aerobic mesophiles parameter. At some staff, the microbiological load of counts of total aerobic mesophiles on hands was 106 cfu/10 cm² and above values (132 of 300 staff, 44%, data not shown).

The marital status and the education variables were effective on the microbiological pollution model of the staff hands due to categorical data for coliforms. *E. coli* and coliforms parameters are related to the same individual variables however much coliforms include additional different species than *E. coli*. According to odds ratio values in the column of Exp (B), the marital status variable was 4.1 times effective on coliforms while the education variable was effective on the same parameter 5.1 times. Insufficient education level (primary and secondary school levels) and being non-married (single or divorced) increased the level of microbiological contamination. Hometown variable effectiveness was determined as 1 time. For the hometown variable, Middle Anatolian, East Anatolian and Southeast Anatolian regions originated staff increased the dirtiness. In the classification table, dirty decided staff were estimated at a rate of 90.7% and clean decided staff were estimated at a rate of 89.8%. Coliforms parameter also state the existence of the microorganisms included in Enterobacteriaceae family such as *Salmonella*, *Shigella*, *Yersinia*, *Proteus* and *Klebsiella* on behalf of *E. coli* and all the microorganisms mentioned above are important risk factors for the food security⁵¹. De Wit & Rombouts⁵² indicate that high values of coliforms points inadequate hygienic applications and non-applied toilet hygiene procedures and hand washing rules. Similarly, the effective factors for coliforms parameter were the marital status and the education variables in our study. We

think that, to gain hand washing habit and to apply hand washing rules (to use correct and suitable chemicals, sufficient time and drying hands) is directly related with educational status. Besides, we can say that, unconsciousness about the probable damages of pathogens is too, directly related with the education level due to our findings. The marital status variable (divorcement and being single) was 4.1 times effective on coliforms parameter. According to the study team, to continue a regular life and integrity of family life is quite effective on individual's hygiene. Also we think that general hygiene of a person is due to stableness of psychological situation as much as education.

For *E. coli* parameter, detailed results of categorical data indicate that the marital status and the education variables were effective on the microbiological contamination model of the staff's hands. The education variable (education level at primary or secondary school) and divorcement increased the contamination of the staff's hands and was evaluated as critical individual variables that risk consumers' health and product hygiene for our model. Due to the model outputs, the marital status and the education variables were statistically significant on *E. coli* parameter at P<0.05 level. According to odds ratio values in the column of Exp (B), the marital status variable was 4.6 times effective on coliforms while the education variable was effective on the same parameter 5.4 times. In the classification table, dirty decided staff were estimated at a rate of 92.1% and clean decided staff were estimated at a rate of 93.3%. Legnani et al.⁵³, indicate that the values of *E. coli* for staff hands and surfaces must not be above the value of 1 cfu/cm². Similarly in our study, we accepted 0 cfu/cm² value as hygienic and acceptable for our regional data and microbiological contamination model. The values above the mentioned levels were decided as non-acceptable for both two parts of the study and evaluated as a risk factor. Moreover, we want to remind that *E. coli* (+) staff may have a high potential risk of carrying pathogen serotypes like *E. coli* O111 and *E. coli* O157:H7 in spite of serotyping analysis were not performed by the study team. Low education level increased the microbiological contamination for *E. coli* in our study, and our results are parallel to the findings of Aycicek et al.⁵⁴. The scientists indicate that, they analyzed directly food contact staff at 30 food plants and found 7.8% of *E. coli* (+) staff. The same scientists also point out that *E. coli* (+) staff's had a low degree of socio-economic position⁵⁴. Aktan et al.⁵⁵, also stated that staff with

low education level have a high risk of carrying *E. coli* and in a study of them, they isolated *E. coli* with a rates of 37.5% and 41.7% at the staff before and during work respectively in hospital kitchens established at rural areas.

For *S. aureus* parameter, again, the marital status and the education variables were effective. The mentioned variables were determined as significant at $P < 0.05$ level. However, gender, age, children, hometown and position variables were not determined as significant for *S. aureus* ($P > 0.05$). According to odds ratio values in the column of Exp (B), the marital status variable was 2 times effective on coliforms while the education variable was effective on the same parameter 4 times. In the classification table, dirty decided staff were estimated at a rate of 92.7% and clean decided staff were estimated at a rate of 91.5%. *S. aureus*, is known to be predominant species for food borne intoxication cases caused by *Staphylococci*⁵⁶. Microorganisms living on human skin basically separate into two groups. The first group is permanent agents and the second group is temporary microorganisms. *S. aureus*, is the only pathogen and permanent microorganism on human skin^{54,56-60}. We think that the education and the marital status variables effects hand washing habit. Even effective and frequent hand washing and taking shower transactions can not totally eliminate *S. aureus*. The individual variables match the contamination ways of *S. aureus*. According to Moore et al.⁶¹, direct food contact surfaces and the staff is the most important contamination way of *S. aureus*.

According to the t test results, we can arrange the regions generally in order from clean to dirty due to the microbiological parameters analyzed; Marmara, Aegean, Blacksea, Mediterrenean and Middle Anatolian (data not shown). When the geographical regions analyzed two by two, again the region that has the highest microbiological contamination rate due to the staff hands was Middle Anatolian region. According to the data of Turkish Government Institute of Statistics⁶², the Middle Anatolian is the region that includes the maximum count of families that have 10 and above household in the same house in the five geographical region of Turkey (109,195 families). This is even higher than the Marmara region (54,951 families), that include İstanbul, the most crowded and biggest city of Turkey⁶². According to these data, we think that the demographic construction and the number of household parameters can indirectly effect the

public health and food hygiene negatively.

To determine microbiological contamination at the last form of the food products is a very important process for consumers' health, but unfortunately this process is not able to prevent the contamination at the process stage and cause economic losses. To take into consideration regional properties, demographic position, traditional characteristics of the regions, the individual variables of the staff candidate - as in our study - beside medical processes while establishing food security systems at food plants will be very effective to reduce risk factors for consumers' health and prevalence of food borne diseases and outbreaks.

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