Listeria monocytogenes in Dairy Products of the Middle East Region: A Systematic Review, Meta-Analysis, and Meta-Regression Study

Moein Bashiry¹, Fardin Javanmardi², Musarreza Taslikh², Zhaleh Sheidaei², Ehsan Sadeghi¹, Abdol-Samad Abedi², Adel Mirza Alizadeh², Fataneh Hashempour-Baltork², Samira Beikzadeh², Seyed Mohammad Riahi³, *Hedayat Hosseini², *Amin Mousavi Khaneghah⁴

1. Department of Food Science and Technology, School of Nutrition Science and Food Technology, Kermanshah University of Medical Sciences, Kermanshah, Iran
2. Department of Food Science and Technology, National Nutrition & Food Technology Research Institute, Faculty of Nutrition Sciences & Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran
3. Department of Epidemiology and Biostatistics, Cardiovascular Diseases Research Center, School of Medicine, Birjand University of Medical Sciences, Birjand, Iran
4. Department of Food Science and Nutrition, Faculty of Food Engineering, University of Campinas (UNICAMP), Rua Monteiro Lobato, São Paulo, Brazil

*Corresponding Author: Email: hedayat@sbmu.ac.ir, mousavi@unicamp.br
(Received 15 Dec 2020; accepted 21 Mar 2021)

Abstract
Background: The contamination of food products by Listeria monocytogenes as a pathogen bacterium, threatening public health and raised a global concern for a long time. Dairy and meat products and ready-to-eat foods are recognized as the most common carriers for L. monocytogenes.

Methods: The related reports of the prevalence of L. monocytogenes in dairy products in Middle East countries from 2009 to 2020 were screened through some of the international databases such as Science Direct, Web of Science, Scopus, PubMed, and Google Scholar. While a random effect model was applied to estimate pooled or overall prevalence, 95% confidence intervals (95%CI) were used.

Results: Results showed severe heterogeneity (84.2%) in studies and estimated the overall prevalence of L. monocytogenes dairy food products from the Middle East region of 3.5% (CI: 2.2-5). The highest and lowest prevalence was associated with Jordan (17.6% CI: 9.8-26.9) and Iraq (1.6% CI: 0.3-3.7), respectively. Based on the type of product, the highest and lowest prevalence of L. monocytogenes was recognized for raw cow milk (5.8% CI: 2.7-9.7) and pasteurized cow milk (1.1% CI: 0-8), respectively.

Conclusion: There is no justification for severe heterogeneity (I²) of subgroups as prevalence is heterogenic innately, but Jordan and row cow milk subgroups were found to have a considerable effect on overall pooled prevalence. Thus, they were the reason for prevalence changes.

Keywords: Listeria monocytogenes; Dairy products; Middle East; Systematic review; Meta-analysis
Introduction

Listeria is a genus from the Listeriaceae family that includes more than 20 species categorized into three main clades (1). It is a facultatively anaerobic, gram-positive, non-spore forming, and psychrotrophic bacterium (2). Some Listeria species are recognized as pathogenic such as L. monocytogenes, known as pathogens for both humans and animals, and L. ivanovii is considered pathogenic for animals (3). L. monocytogenes are highly important in terms of public health and grow easily at temperatures ranging from -0.4 °C to 45°C and tolerate osmotic stress up to 14% salt concentration. It also can undergo a broad zone of pH 4.0 to 9.6 (optimum pH 6–8). The water activity of 0.90 is distinguished as the lowest level of water activity that L. monocytogenes can survive (4, 5).

Listeriosis resulted from the consumption of contaminated food products by L. monocytogenes such as cheese, non-pasteurized milk, unwashed raw vegetables, and undercooked meat, and it is identified as one of the primary foodborne diseases for humans (6-10). The contamination of milk by L. monocytogenes is attributed to both infected and healthy animals besides poor hygiene conditions or practices (11, 12). Therefore, among different foods, milk, mainly raw milk, and other kinds of dairy products are particular sources for L. monocytogenes.

L. monocytogenes threaten human health by causing listeriosis. At the same time, diarrhea, vomiting, fever, headache, gastroenteritis, and myalgia are mild symptoms. Moreover, septicemia and meningitis that commonly resulted in stillbirth and abortion in pregnant women are the common invasive symptoms (8, 10, 13). According to the Center for Diseases Control (CDC), 467 listeriosis cases and 83 deaths were reported between 2011 and 2017 in the different states of the USA (14), while the number of confirmed cases of listeriosis reported by EU/EEA countries in 2016 was 2555 (15). Available data about the listeriosis epidemiology in the Middle East, especially Iran, are rare. Because in the Iranian health system, listeriosis cases are not reported precisely (16).

Studies for investigating the prevalence of Listeria spp. have been conducted based on different groups of foods, including meat, seafood, milk, dairy products, ready-to-eat foods, and eggs (4, 17). Contamination is different in various regions due to differences in livestock procedures conditions, storage and hygiene conditions, and technological practices (17). Several studies were carried out on the prevalence of L. monocytogenes. These studies do not have a specific pattern, and researchers have been reported inconsistencies in different regions like Iran, Egypt, and Italy. For instance, an Iranian research group represented 37% of raw milk samples contaminated with L. monocytogenes (18). However, some other researchers (19-21) described no contamination for L. monocytogenes in raw milk. Moreover, L. monocytogenes was detected in fifty percent of cheese samples (22), while other authors (20, 23) could not find L. monocytogenes in Iranian cheese samples. Besides, Kabuki et al. isolated L. monocytogenes in 6.3% of Iranian cheese samples (24). Inconsistent statistics in L. monocytogenes prevalence in dairy products are also reported in other countries. For instance, in Egypt, L. monocytogenes range from 3.3 to 6.6% in milk products (25), and researchers in other countries like Syria reported that Listeria spp. exists in 10.96% of raw milk samples (26), or L. monocytogenes was positive in 4.8% of cheese samples in Turkey (27). Dairy product contamination with L. monocytogenes has been reported for European countries as well. For example, contamination of 2.2% was reported for Italian raw milk with L. monocytogenes (28). Furthermore, meta-analysis research conducted in Europe using EFSA reports and prior studies about the prevalence, contamination of L. monocytogenes in different cheese types showed the prevalence from 0.8 to 11.8% in European countries (29).

Although many studies have estimated the prevalence value of Listeria spp. in different food samples, no systematic review or meta-analysis regarding L. monocytogenes contamination of milk products in the Asian or the Middle East coun-
tries was reported cohesively. Hence, summarizing research from different databases that studied *L. monocytogenes* contamination in the Middle East countries in dairy products and considering the risk of bias assessment was the objective of this work.

**Methods**

**Search scheme**

According to the Cochrane protocol (PRISMA guideline), this systematic review and meta-analysis study was carried out (30). In the first step, Science Direct, Web of Science, Scopus, PubMed, and Google Scholar databases were used to retrieve published original studies in the Middle East countries between 2009 and 2020. The following search keywords and MeSH terms were used: (Cheese OR Cream OR Kashk OR Milk OR "Dairy Products" OR "Ice cream" OR Butter OR Yoghurt OR Ghee OR Buttermilk OR Kefir OR Koumiss OR Whey) AND ("*Listeria monocytogenes*" OR "L_monocytogenes") AND ("The Middle East" OR Afghanistan OR Bahrain OR Iran OR Iraq OR Israel OR Jordan OR Kuwait OR Lebanon OR Oman OR Qatar OR Saudi Arabia OR Syria OR Turkey OR United Arab Emirates OR Yemen) AND (Prevalence OR Outbreak OR Incident OR Contamination). Searching in the mentioned databases and screening was conducted. The title, abstract, and full text of retrieved articles were screened for eligibility. Moreover, to cover almost all papers, the references list of reviewed articles was considered.

**Inclusion/exclusion criteria**

The articles' selection was based on our research criteria by two reviewers separately after screening the databases with the same keywords and procedures. In this step, each author was responsible for reviewing the papers in all parts (titles, abstracts, and full texts) to select the articles having the inclusion criteria; any differences were supposed to be resolved by consensus. Articles included in this study based on inclusion criteria (Eligibility criteria) including only dairy product samples, researches were done and reported in the middle east countries, available full-text in the English language; cross-sectional descriptive studies; *L. monocytogenes* detection done with high accuracy technique (culture and PCR techniques); and prevalence data was presented clearly in the results of papers. Moreover, any other food samples like meat products or ready-to-eat-foods, reported prevalence of *L. monocytogenes* in other countries, genetic, ecological, animal studies, case reports, thesis, books, non-English articles, and review articles were excluded (Fig. 1).

**Data extraction and risk of bias assessment**

Required data from selected articles including first author, publication year, method of *L. monocytogenes* detecting, type of dairy products, country, study area (province), sample size, and positive samples were extracted by two authors separately. Additionally, assessing the risk of bias of included studies was judged independently by the first author based on the JBI checklist with a minor modification (31).

**Meta-analysis of data**

In this meta-analysis, we applied random effect models for estimating pooled or overall prevalence and 95% confidence intervals (95%CI). The positive samples (p) divided into the total sample (n) indicates the prevalence of *L. monocytogenes* in the dairy products (p=n/n). Overall prevalence was estimated using a Freeman-Tukey double arcsine transformation. Estimation of prevalence *L. monocytogenes* was performed using the Meta-prop command (32). F statistics and Cochran's Q Heterogeneity were used for exploring heterogeneity among studies. F is a variance variable (prevalence) divided by Q value. F ranges between 0-100 percent, and F >70% were considered heterogeneous (33, 34). A Forest plot was used to show *L. monocytogenes* prevalence. In this study, subgroup analysis and meta-regression were performed to explore heterogeneity sources (35). Publication bias was not tested in this study because its aim is not to estimate the association between exposures and outcomes (35). Meta-
Results and discussion

This systematic review and meta-analysis study was carried out on 76 key measures calculated from 32 papers related to dairy products. Articles included in this systematic review and meta-analysis from each country (the Middle East) were summarized in Table 1. Iran (n=13) and Turkey (n=10) had the most considerable number of articles on the prevalence of L. monocytogenes. However, some other countries like Kuwait, Bahrain, and Yemen found no related publication in this field. In this research, dairy products were...
divided into eight main sub-groups, in which most studies included cheese and raw cow milk, as well as the overall prevalence for the presence of *L. monocytogenes* in dairy products, is illustrated in Fig. 2, which was 3.5 % (CI: 2.2%-5.0%).

**Table 1:** Summary of the studies reporting the Prevalence of *Listeria monocytogenes* in dairy products in the Middle East countries

| Id | Assessment technique | Food groups | Country | Region | Year | Sample size | Positive samples | Quality assessment | Ref. |
|----|----------------------|-------------|---------|--------|------|-------------|------------------|-------------------|------|
| 1  | PCR                  | Cheese      | Iran    | Tehran | 2012-2015 | 70 | 5 | 7 | (46) |
|    |                      | Cream       |         |        |      | 20 | 2 | 7 |      |
|    |                      | Kashk       |         |        |      | 17 | 2 | 6 |      |
| 2  | PCR                  | Raw cow milk Cheese | Turkey | Samsun | 2011-2012 | 100 | 5 | 7 | (47) |
|    |                      | Ice cream   |         |        |      | 70 | 9 | 7 |      |
|    |                      | Cream       |         |        |      | 20 | 0 | 7 |      |
|    |                      |             |         |        |      | 20 | 0 | 7 |      |
| 3  | PCR                  | Raw cow milk Cheese | Iran | - | 2013-2015 | 37 | 1 | 7 | (48) |
|    |                      |             |         |        |      | 130 | 4 | 7 |      |
| 4  | PCR                  | Raw cow milk Cheese | Turkey | Southern Marmara | 2009-2010 | 42 | 0 | 7 | (49) |
|    |                      | Cheese      |         |        |      | 140 | 0 | 7 |      |
|    |                      | Cream       |         |        |      | 12 | 0 | 6 |      |
|    |                      | Yogurt      |         |        |      | 2 | 0 | 6 |      |
| 5  | PCR                  | Raw cow milk Raw sheep Milk Cheese | Iran | Tehran | 2008-2010 | 240 | 13 | 7 | (41) |
|    |                      |             |         |        |      | 206 | 5 | 7 |      |
| 6  | Culture              | Raw cow milk Cheese | Turkey | Van otlu | 2011 | 120 | 34 | 7 | (50) |
| 7  | Culture              | Raw cow milk Cheese | Turkey | Sakarya | 2008-2010 | 8 | 0 | 8 | (51) |
|    |                      |             |         |        |      | 8 | 0 | 8 |      |
| 8  | Culture              | Raw cow milk Pasteurized cow milk | Turkey | Aydin | 2013 | 20 | 5 | 7 | (52) |
|    |                      | Yogurt      |         |        |      | 20 | 1 | 7 |      |
|    |                      | Cheese      |         |        |      | 40 | 2 | 7 |      |
|    |                      | Cream       |         |        |      | 50 | 5 | 7 |      |
|    |                      |             |         |        |      | 10 | 1 | 7 |      |
| 9  | Culture              | Raw cow milk Cheese | Iran | Tabriz | 2014 | 18 | 9 | 7 | (22) |
| 10 | Culture              | Raw cow milk Cheese | Jordan | Karak | 2011 | 20 | 9 | 7 | (36) |
|    |                      | Yogurt      |         |        |      | 20 | 7 | 7 |      |
|    |                      |             |         |        |      | 20 | 8 | 7 |      |
| 11 | PCR and Culture      | Raw cow milk Raw sheep Milk | Iran | Fars and Khuzestan | 2010-2011 | 156 | 3 | 8 | (10) |
|    |                      |             |         |        |      | 104 | 2 | 8 |      |
| 12 | PCR and Culture      | Raw cow milk Egypt | Sharkia Governorate | 2015-2016 | 100 | 25 | 8 | (22) |
| 13 | PCR                  | Kashk Cheese | Lebanon | Bekaa Valley | 2009 | 83 | 6 | 8 | (43) |
|    |                      |             |         |        |      | 81 | 17 | 8 |      |
| 14 | Culture              | Raw cow milk Pasteurized cow milk | Iran | Sari | 2013 | 100 | 0 | 8 | (19) |
|    |                      |             |         |        |      | 100 | 0 | 8 |      |
| 15 | PCR                  | Pasteurized cow | Iran | - | 2011 | 596 | 61 | 8 | (54) |
| No. | Method | Product            | Country   | Year范围 | Positive (%) | PCR | Culture |
|-----|--------|--------------------|-----------|----------|--------------|-----|---------|
| 16  | PCR    | Raw cow milk       | Egypt     | 2013     | 100          | 1   | 5       |
| 17  | PCR    | Cheese             | Turkey    | 2015     | 104          | 17  | 6       |
|     |        | Pasteurized cow milk | Turkey    | 2012     | 10           | 0   | 7       |
| 18  | PCR and Culture | Raw cow milk    | Iran      | 2013     | 60           | 1   | 7       |
|     | Culture | Cheese            | Jordan    | 2015     | 20           | 0   | 7       |
|     | Ice cream | -             | Erzurum   | 2012     | 10           | 0   | 7       |
| 19  | PCR    | Raw cow milk       | Iran      | 2015     | 60           | 0   | 7       |
|     | Culture | Cheese            | Jordan    | 2017     | 150          | 8   | 7       |
| 20  | PCR and Culture | Raw cow milk    | Iran      | 2016     | 140          | 11  | 8       |
|     | Culture | Cheese            | Yazd      | 2016     | 220          | 10  | 8       |
|     | Ice cream | -             | -         | 2016     | 100          | 1   | 8       |
|     | Cream   | -                | -         | 2016     | 85           | 0   | 8       |
| 21  | PCR and Culture | Raw cow milk    | Iran      | 2016     | 140          | 11  | 8       |
|     | Culture | Cheese            | Yazd      | 2016     | 220          | 10  | 8       |
|     | Ice cream | -             | -         | 2016     | 100          | 1   | 8       |
|     | Cream   | -                | -         | 2016     | 85           | 0   | 8       |
| 22  | Culture | Ice cream          | Iran      | 2013     | 67           | 0   | 8       |
|     | Pasteurized cow milk | -             | Kermanshah | 2013  | 59           | 0   | 8       |
|     | Cheese  | -                | -         | 2013     | 59           | 0   | 8       |
| 23  | PCR and Culture | Raw cow milk    | Iran      | 2011     | 100          | 5   | 6       |
|     | Culture | Cheese            | Kerman    | 2011     | 100          | 5   | 6       |
| 24  | PCR and Culture | Raw cow milk    | Iran      | 2007-2009 | 138         | 1   | 8       |
|     | Culture | Cheese            | Isfahan   | 2007-2009 | 122         | 6   | 8       |
|     | Ice cream | -             | -         | 2007-2009 | 90          | 9   | 8       |
|     | Yogurt  | -                | -         | 2007-2009 | 136         | 2   | 8       |
|     | Cream   | -                | -         | 2007-2009 | 130         | 0   | 8       |
|     | Kashk   | -                | -         | 2007-2009 | 40          | 1   | 8       |
|     | Yogurt  | -                | -         | 2007-2009 | 71          | 0   | 8       |
| 25  | Culture | Cheese            | Turkey    | 2010-2011 | 100         | 3   | 7       |
|     | Yogurt  | -                | Balikeshir | 2010-2011 | 100         | 5   | 7       |
| 26  | PCR    | Cheese            | Egypt     | 2013-2014 | 50           | 0   | 8       |
|     | Raw cow milk | -             | El Giza   | 2013-2014 | 50           | 4   | 8       |
| 27  | Culture | Raw cow milk       | Iran      | 2010     | 120          | 3   | 7       |
|     | Cheese  | -                | Noorabad  | 2010     | 60           | 3   | 7       |
|     | Yogurt  | -                | -         | 2010     | 180          | 0   | 7       |
| 28  | PCR    | Cheese            | Jordan    | 2011     | 350          | 39  | 7       |
|     | Culture | Pasteurized cow milk | Turkey    | 2012     | 10           | 0   | 6       |
|     | Cheese  | -                | Bursa     | 2012     | 10           | 0   | 6       |
|     | Ice cream | -             | -         | 2012     | 60           | 1   | 7       |
|     | Cream   | -                | -         | 2012     | 20           | 0   | 7       |
|     | -       | -                | -         | 2012     | 10           | 0   | 6       |
| 30  | Culture | Row cow milk       | Jordan    | 2016     | 305          | 32  | 8       |
|     | Cheese  | -                | Turke y   | 2016     | 40           | 0   | 8       |
|     | Ice cream | -             | Bolu      | 2016     | 27           | 0   | 8       |
| 31  | PCR    | Cheese            | Turkey    | 2019     | 20           | 0   | 8       |
|     | Ice cream | -             | Hatay     | 2019     | 20           | 0   | 8       |
| 32  | Culture | Cheese            | Iraq      | 2016-2017| 121          | 1   | 8       |
|     | Ice cream | -             | Dehok     | 2016-2017| 121          | 1   | 8       |
| 33  | PCR    | Cheese            | Iraq      | 2016-2017| 118          | 3   | 8       |

Available at: [http://ijph.tums.ac.ir](http://ijph.tums.ac.ir)
Ice cream had the lowest mean prevalence of 0.0% (CI: 0.0-1.1%), followed by cream 0.6% (CI: 0.0-2.9%), pasteurized cow milk 1.1% (CI: 0.0-8.0%), yogurt 1.6% (CI: 0.0-10.4%), raw ship milk 2.8% (CI: 1.5-4.4%), Kashk 3.8% (CI: 0.0-14.8%), cheese 5.5% (CI: 2.8-8.9%) and raw cow milk had the highest L. monocytogenes prevalence of 5.8% (CI: 2.7-9.7%). On the other hand, the prevalence rank order in terms of country showed the following order: Iraq 1.6% (CI: 0.3-3.7%), Turkey 2.2% (CI: 0.3-5.1%), Iran 2.5% (CI: 1.2-4.3%), Egypt 5.8% (CI: 0.2-20.6%), Lebanon...
The highest level of *Listeria monocytogenes* contamination in cheese (Fig. 3) was observed in Jordan with 35% contamination (CI: 15.4-59.2%) (36).

Moreover, the highest and lowest *L. monocytogenes* incidence in raw ship milk was observed in two studies carried out (10, 37) in Iran, which found values of 4.9 and 1.9%. The main reason cheese...
faced a high prevalence of *L. monocytogenes* is probably related to raw milk origin and survival ability of *L. monocytogenes* in high salt concentration and resistance to different pH (38). *L. monocytogenes* can survive in some cheeses like white cheese after several weeks, dangerous for public health. The estimated mean prevalence of *L. monocytogenes* in cheese products in the Middle East (5.5%) was more than results from European reports (2.3%) (3). The only study on *L. monocytogenes* contamination in Iraq reported a mean prevalence of 1.6% (CI: 0.3%-3.7%) in cheese and raw ship milk (39). Milk contamination of *L. monocytogenes* is not specific to raw cow milk, but also pasteurized cow milk could carry *L. monocytogenes* in case of inadequate pasteurization or post-pasteurization contamination. Furthermore, the high prevalence of *L. monocytogenes* in raw milk could be associated with animal infection or contamination of livestock feed, and contamination of raw milk during breastfeeding and milk storage could be another reason (40, 41). Similarly, in a study conducted by the EU’s Rapid Alert System for Food and Feedstuff between 2004 and 2009, 97 dairy products were positive for *Listeria* and 34 of them were pasteurized, and 22 samples were raw milk products (42). Moreover, the highest occurrence rate of *L. monocytogenes* in yogurt was found in Jordan (36), that 40% of samples were contaminated with *L. monocytogenes*. Moreover, in the only study on *L. monocytogenes* contamination in Lebanon, they reported a mean prevalence of 13.3% (CI: 8.4%-19%) in cheese and Kashk (43). According to the results of this meta-analysis, contamination of cream and ice cream by *L. monocytogenes* was low.

Generally, occurrence evaluation of *L. monocytogenes* is necessary for dairy products as they are vehicles for this pathogen transmission that led to the highest death rate among infectious diseases (44). Preventing foods, especially dairy products, from being contaminated by *L. monocytogenes* is highly recommended. Additionally, adequate pasteurizing, forage quality, housing facilities, and milking hygienic conditions can affect milk’s microbial quality (45).

The meta-regression test investigates potential contributing parameters that affect study heterogeneity. This test was used to examine the year of publication and the quality score for each included study in our study. The year of publication's meta-regression plot versus *L. monocytogenes* prevalence in dairy products showed no significant relationship (C=0.0006; P=0.88). As shown in Fig. 4, regarding the effect sizes of the research studies; there is a tendency to decrease in *L. monocytogenes* prevalence over the years between 2010 and 2020, which seems that during these years, various factors, including hygienic-sanitary quality of milk, storage conditions, and pasteurization method has improved as well as post-pasteurization contamination reduced. Generally, hygienic procedures in the Middle East have been introduced to some extent for quality improvement over the last decade. In this study, the quality assessment of research studies was conducted. We evaluated the methodological quality of the 32 research reports, using nine quality criteria relating to the prevalence studies. The items were determined to consist of sampling method, sample size adequacy, subject description in detail, data coverage analysis, applying valid method, response rate adequacy, using the standard method, and using appropriate statistical analysis. A meta-regression analysis was used to find the relationship between *L. monocytogenes* occurrence rate and the quality score of the included study. Figure 5 indicated that included papers' quality scores have no considerable effects on the prevalence of *L. monocytogenes* in dairy products.
Fig. 4: The relationship between the prevalence *Listeria monocytogenes* with year of study

Fig. 5: The relationship between the prevalence of *Listeria monocytogenes* with quality score for included study
There are some limitations to this study. Although our search was comprehensive, there were limited studies in some countries or finding no studies on *L. monocytogenes* contamination. Moreover, no study was found about *Listeria* contamination in some samples, such as Kefir or Komis. Another limitation was that some of the available studies had limited sample sizes or a lack of data on *Listeria* contamination, or no full-text access. Despite these limitations, the authors tried to cover all the studies done in the Middle East region and showed a general view of the prevalence of *L. monocytogenes*. Moreover, researchers suggest that researchers aim to carry out secondary review articles (systematic review and meta-analysis study) to limit and make narrower the type of reviewed food samples and possibly widen reviewed regions. It helps to draw a much better image of the prevalence of *L. monocytogenes* in the world and finds critical and threatening points in *L. monocytogenes* contaminations affecting public health. Similarly, risk assessment studies for this pathogen in different dairy products in different regions and countries and even worldwide are suggested for future original research.

**Conclusion**

The prevalence of *L. monocytogenes* in dairy products in the Middle East based on defined subgroups was systematically reviewed and meta-analyzed. The order of contamination by *L. monocytogenes* among the investigated dairy products based on prevalence was raw cow milk > cheese > Kashk > raw ship milk > yogurt > pasteurized cow milk > cream > ice cream, demonstrating the required further attention in the production process of some products such as cheese and Kashk. The high prevalence of *L. monocytogenes* in some dairy products is probably related to the unhealthy production method and lack of adequate pasteurization temperature in these products, as well as environmental contamination by animal wastes, which can be a reason for this contamination. Consumption of raw milk and its products, especially cheese produced with insufficient heat treatment and the lack of appropriate control measures, might cause serious health problems.

**Ethical considerations**

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

**Acknowledgements**

Research reported in this publication was supported by Elite Researcher Grant Committee under award number 984086 from the National Institutes for Medical Research Development (NI-MAD), Tehran, Iran.

**Conflict of interest**

The authors declare that there is no conflict of interest.

**References**

1. Weller D, Andrus A, Wiedmann M, den Bakker HC (2015). *Listeria* booriae sp. nov. and *Listeria* newyorkensis sp. nov., from food processing environments in the USA. *Int J Syst Evol Microbiol*, 65(Pt 1):286-92.
2. Navratilova P, Schlegelova J, Sustackova A, Napravnikova E, Lukasova J, Klimova E (2004). Prevalence of *Listeria monocytogenes* in milk, meat and foodstuff of animal origin and the phenotype of antibiotic resistance of isolated strains. *Vet Med*, 49(7):243-252.
3. Martinez-Rios V, Dalgaard P (2017). Prevalence of *Listeria monocytogenes* in European cheeses: A systematic review and meta-analysis. *Food Control*, 84(4):205-14.
4. Hamidiyan N, Salehi-Ahargouei A, Rezaei Z, et al (2018). The prevalence of *Listeria* spp. food contamination in Iran: A systematic review and meta-analysis. *Food Res Int*, 107:437-50.
5. Välimaa A-I, Tilsala-Timsjärvi A, Virtanen E (2015). Rapid detection and identification
method for *Listeria monocytogenes* in the food chain—a review. *Food Control*, 55(12):103-14.
6. McLauchlin J (1997). The pathogenicity of *Listeria monocytogenes*: a public health perspective. *Rev Med Microbiol*, 8:1-14.
7. Ayyun O, Pehlivantar S (2006). *Listeria* spp. in the raw milk and dairy products in Antakya, Turkey. *Food Control*, 17(8):676-9.
8. Akrami-Mohajeri F, Derakhshan Z, Ferrante M, et al (2018). The prevalence and antimicrobial resistance of *Listeria* spp in raw milk and traditional dairy products delivered in Yazd, central Iran. *Food Chem Toxicol*, 114:141-4.
9. Oliver SP, Jayarao BM, Almeida RA (2005). Foodborne pathogens in milk and the dairy farm environment: food safety and public health implications. *Foodborne Pathog Dis*, 2(2):115-29.
10. Rahimi E, Ameri M, Momtaz H (2010). Prevalence and antimicrobial resistance of *Listeria* species isolated from milk and dairy products in Iran. *Food Control*, 21(11):1448-52.
11. Wagner M, Lehner A, Klein D, Buber A (2000). Single-strand conformation polymorphisms in the hly gene and polymerase chain reaction analysis of a repeat region in the iap gene to identify and type *Listeria monocytogenes*. *J Food Prot*, 63(3):332-6.
12. Hassan I, Mohammed HO, McDonough PL (2001). Farm-management and milking practices associated with the presence of *Listeria monocytogenes* in New York state dairy herds. *Prev Vet Med*, 51(1-2):63-73.
13. World Health Organization & Food and Agriculture Organization of the United Nations (2004). Risk assessment of *Listeria monocytogenes* in ready-to-eat foods : technical report. FAO.
14. CDC (2018). Centers for Disease Control and Prevention National Enteric Disease Surveillance. https://www.cdc.gov/nationalsurveillance
15. ECDC (2018). Surveillance report: Annual Epidemiological Report. https://www.ecdc.europa.eu/en/surgical-site-infections/surveillance-and-disease-data/all-annual-epidemiological-reports
16. Zahedi Bialvaei A, Sheikhalizadeh V, Mojtahedi A, Irajian G (2018). Epidemiological burden of *Listeria monocytogenes* in Iran. *Irran J Basic Med Sci*, 21(8):770-80.
17. Sarfraz M, Ashraf Y, Ashraf S (2017). A Review: Prevalence and antimicrobial susceptibility profile of *Listeria* species in milk products. *Matrix Sci Med*, 1(1):13-25.
18. Jami S, Jamshidi A, Khanzadi S (2010). The presence of *Listeria* spp. in raw milk samples in Mashhad, Iran. *World Appl Sci J*, 10(2):249-53.
19. Vahedi M, Nasrolahi M, Sharif M, Mirabi AM (2013). Bacteriological study of raw and unexpired pasteurized cow's milk collected at the dairy farms and super markets in Isfahan city in 2011. *J Prev Med Hyg*, 54(2):120-3.
20. Jalali M, Abedi D (2008). Prevalence of *Listeria* species in food products in Isfahan, Iran. *Int J Food Microbiol*, 122(3):336-40.
21. Akya A, Najafi F, Moradi J, Mohebi Z, Adabagher S (2013). Prevalence of food contamination with *Listeria* spp. in Kermanshah, Islamic Republic of Iran. *East Mediterr Health J*, 19(5):474-477.
22. Moosavy M-H, Esmaeili S, Mostafavi F, Amiri FB (2014). Isolation of *Listeria monocytogenes* from milks used for Iranian traditional cheese in Lighvan cheese factories. *Ann Agric Environ Med*, 21(4):728-9.
23. Shamloo E, Jalali M, Mirlohi M, Madani G, Metcalf D, Merasi MR (2015). Prevalence of *Listeria* species in raw milk and traditional dairy products in Isfahan, Iran. *Int J Environ Health Eng*, 4:1.
24. Kabuki D, Kuaye A, Wiedmann M, Boor K (2004). Molecular subtyping and tracking of *Listeria monocytogenes* in Latin-style fresh-cheese processing plants. *J Dairy Sci*, 87(9):2803-12.
25. Ismaiel AA-R, Ali AE-S, Eman GJFS (2014). Biotechnology. Incidence of *Listeria* in Egyptian meat and dairy samples. *Food Sci Biotechnol*, 23:179-85.
26. Al-Mariri A, Younes A, Ramadan I. (2013). Prevalence of *Listeria* spp. in raw milk in Syria. *Br J Vet Med*, 16(2):112-122.
27. Kahraman T, Ozmen G, Ozinan B, Omer Goksoy E (2010). Prevalence of *Salmonella* spp. and *Listeria monocytogenes* in different cheese types produced in Turkey. *Br Food J*, 112(11):1230-6.
28. Dalzini E, Bernini V, Bertasi B, et al (2016). Survey of prevalence and seasonal variability of *Listeria monocytogenes* in raw cow milk from Northern Italy. *Food Control*, 60:466-70.
29. Veronica M-R, Paw D (2018). Prevalence of Listeria monocytogenes in European cheeses: A systematic review and meta-analysis. Food Control, 84:205-14.
30. Liberati A, Altman DG, Tetzlaff J, et al (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med, 6(7):e1000100.
31. Institute JB (2017). The Joanna Briggs Institute critical appraisal tools for use in JBI systematic reviews: checklist for prevalence studies. Crit Apprais Checkl Prevail Stud, 54(1):12-21.
32. Nyaga VN, Arbyn M, Aerts M (2014). Metaprop: a Stata command to perform meta-analysis of binomial data. Arch Public Health, 72(1):39.
33. Higgins J (2008). Assessing risk of bias in included studies. The Cochrane Collaboration. Chichester, UK: Wiley-Blackwell.
34. Riahi SM, Mokhayeri Y (2017). Methodological issues in a meta-analysis. Curr Med Res Opin, 33(10):1813.
35. Mokhayeri Y, Riahi SM, Rahimzadeh S, et al (2018). Metabolic syndrome prevalence in the Iranian adult’s general population and its trend: a systematic review and meta-analysis of observational studies. Diabetes Metab Syndr, 12(3):441-53.
36. Omar SS, Dababneh BF, Qatatsheh A, et al (2011). The incidence of Listeria species and other indicator bacteria in some traditional foods sold in Karak city, Jordan. J Food Agric Environ, 9(2):79-81.
37. Rahimi E, Momtaz H, Behzadnia A, Baghbadorani ZT (2014). Incidence of Listeria species in bovine, ovine, caprine, camel and water buffalo milk using cultural method and the PCR assay. Asian Pac J Trop Dis, 4(1):50-3.
38. Temelli S, Ata Z, Anar S, et al (2012). Detection of Listeria spp. and Listeria monocytogenes in retail dairy products using the Vitek immunodiagnostic assay system LDUO method and ISO method. Mikrobioliea, 67(4):374-7.
39. Al-Breikani AM, Mamman IM (2019). Seasonal Changes in the Occurrence of Listeria monocytogenes in Duhok Province. Sâ J Univ Zakho, 7(1):5-9.
40. Sağun E, Sancak YC, İşleyici Ö, Ekici K (2001). The presence and prevalence of Listeria species in milk and herby cheese in and around Van. Turk J Vet Anim Sci, 25(1):15-9.
41. Jamali H, Radmehr B, Thong KL (2013). Prevalence, characterisation, and antimicrobial resistance of Listeria species and Listeria monocytogenes isolates from raw milk in farm bulk tanks. Food Control, 34(1):121-5.
42. Morajjema Y, Moy G, Todd E (2014). Encyclopedia of food safety. Academic Press.
43. Harakeh S, Saleh I, Zouhairi O, et al (2009). Antimicrobial resistance of Listeria monocytogenes isolated from dairy-based food products. Sà Total Environ, 407(13):4022-7.
44. EFSA E (2014). European Food Safety Authority. European Centre for Disease Prevention and Control. The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2012. EFSA J, 12(2): 3547-312.
45. Sanaa M, Poutrel B, Menard J, Serieys F (1993). Risk factors associated with contamination of raw milk by Listeria monocytogenes in dairy farms. J Dairy Sci, 76(10):2891-8.
46. Pournajaf A, Rajabnia R, Sedighi M, et al (2016). Prevalence, and virulence determination of Listeria monocytogenes strains isolated from clinical and non-clinical samples by multiplex polymerase chain reaction. Rev Soc Bras Med Trop, 49(5):624-7.
47. Kevenk TO, Gulel GT (2016). Prevalence, Antimicrobial Resistance and Serotype Distribution of Listeria monocytogenes Isolated from Raw Milk and Dairy Products. J Food Saf, 36:11-8.
48. Lotfollahi L, Chaharbalesh A, Rezaee MA, Hasani A (2017). Prevalence, antimicrobial susceptibility and multiplex PCR-serotyping of Listeria monocytogenes isolated from humans, foods and livestock in Iran. Microb Pathog, 107:425-9.
49. Cetinkaya F, Mus TE, Yibar A, et al (2014). Prevalence, serotype identification by multiplex polymerase chain reaction and antimicrobial resistance patterns of Listeria monocytogenes isolated from retail foods. J Food Saf, 34:42-9.
50. Guner A, Telli N (2011). A Survey on the Presence of Listeria monocytogenes in Various
Semi-Hard Cheeses from Different Regions of Turkey. *J Anim Vet Adv*, 10(14):1890-4.

51. Cagri-Mehmetoglu A, Yaldirak G, Bodur T, et al (2011). Incidence of *Listeria monocytogenes* and *Escherichia coli O157:H7* in two Kasar Cheese processing environments. *Food Control*, 22:762-6.

52. Cardak AD (2013). Gross composition and the presence of *Listeria monocytogenes* and *Salmonella* spp. In raw milk and dairy products in Aydin, Turkey. *J Food Agric Environ*, 11(3-4):55-62.

53. Tahoun AB, Elez RMA, Abdelfatah EN, et al (2017). *Listeria monocytogenes* in raw milk, milking equipment and dairy workers: molecular characterization and antimicrobial resistance patterns. *J Glob Antimicrob Resist*, 10:264-70.

54. Dehkordi FS, Barati S, Momtaz H, Ahari SNH, Dehkordi SN (2013). Comparison of Shedding, and Antibiotic Resistance Properties of *Listeria monocytogenes* Isolated From Milk, Feces, Urine, and Vaginal Secretion of Bovine, Ovine, Caprine, Buffalo, and Camel Species in Iran. *Jundishapur J Microbiol*, 6(3):284-94.

55. Osman KM, Samir A, Orabi A, Zolnikov TR (2014). Confirmed low prevalence of *Listeria* mastitis in she-camel milk delivers a safe, alternative milk for human consumption. *Acta Trop*, 130:1-6.

56. Altun SK, Yigin A, Demirci M, et al (2017). Detection of *Listeria monocytogenes* and *Brucella* spp. in a Turkish home-made cecil cheese by real-time PCR. *Res J Biotechnol*, 12(1):78-83.

57. Serhan M, Mattar J (2013). Characterization of four lebanese artisanal goat milk cheeses: Darfiyeh, Aricheh, shankleesh and Serdale by physico-chemical, microbiological and sensory analyses. *J Food Agric Environ*, 11(4):97-101.

58. Haghi F, Zeighami H, Naderi G, et al (2015). Detection of major food-borne pathogens in raw milk samples from dairy bovine and ovine herds in Iran. *Small Rumin Res*, 131:136-40.

59. Al-Groom R (2017). Extant of microbial contamination of cheddar cheese from markets and restaurants in Amman-Jordan. *J Pure Appl Microbiol*, 11(3):1427-33.

60. Mansouri-Najand L, Kianpour M, Sami M, Jajarmi M (2015). Prevalence of *Listeria monocytogenes* in raw milk in Kerman, Iran. *Vet Res Forum*, 6(3):223-6.

61. Cokal Y, Dageeleen A, Cenet O, Gunsen U (2012). Presence of *L. monocytogenes* and some bacterial pathogens in two Turkish traditional foods, Mihalic cheese and Hosmerim dessert. *Food Control*, 26(2):337-40.

62. Reda WW, Abdel-Moein K, Hegazi A, et al (2016). *Listeria* monocytogenes: An emerging food-borne pathogen and its public health implications. *J Infect Dev Ctries*, 10(2):149-54.

63. Mahmoodi MM (2010). Occurrence of *Listeria monocytogenes* in Raw Milk and Dairy Products in Noorabad, Iran. *J Anim Vet Adv*, 9(1):16-9.

64. Osaili TM, Al-Nabulsli AA, Taha MH, et al (2012). Occurrence and antimicrobial susceptibility of *Listeria monocytogenes* isolated from brined white cheese in Jordan. *J Food Sci*, 77(9):MS28-32.

65. Obaibat MM, Stringer AP (2019). Prevalence, molecular characterization, and antimicrobial resistance profiles of *Listeria monocytogenes*, *Salmonella enterica*, and *Escherichia coli O157:H7* on dairy cattle farms in Jordan. *J Dairy Sci*, 102(10):8710-20.

66. Arslan S, Özdemir F (2020). Prevalence and antimicrobial resistance of *Listeria species* and molecular characterization of *Listeria monocytogenes* isolated from retail ready-to-eat foods. *FEMS Microbiol Lett*, 367(4): fnaa006.

67. Unal Turhan E (2019). The presence of pathogenic bacteria in traditional cheese sold in local market in Hatay province, Turkey. *Appl Environ Microbiol*, 17(3):7135-45.

68. Al-Brefkani AMT, Mammani IMA (2019). Characterisation of *Listeria monocytogenes* from Food and Human Clinical Samples at Duhok, Kurdistan Region of Iraq. *J Pure Appl Microbiol*, 13(4):2215-2226.

Available at: [http://ijph.tums.ac.ir](http://ijph.tums.ac.ir)