Epidemiology of *Listeria monocytogenes* prevalence in foods, animals and human origin from Iran: a systematic review and meta-analysis

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Abstract

**Background:** *Listeria monocytogenes* as the main causative agent of human listeriosis is an intracellular bacterium that has the capability to infect a wide range of cell types. Human listeriosis is a sporadic foodborne disease, which is epidemiologically linked with consumption of contaminated food products. Listeriosis may range from mild and self-limiting diseases in healthy people to severe systemic infections in susceptible populations. This study aimed to investigate the prevalence of *L. monocytogenes* in food resources and human samples from Iran.

**Methods:** A systematic search was performed by using electronic databases from papers that were published by Iranian authors since January of 2000 to the end of April 2017. Then, 47 publications which met our inclusion criteria were selected for data extraction and analysis by Comprehensive Meta-Analysis Software.

**Results:** The pooled prevalence of *L. monocytogenes* in human origin was 10% (95% CI: 7–12%) ranging from 0 to 28%. The prevalence of *L. monocytogenes* in animals was estimated at 7% (95% CI: 4–10%) ranging from 1 to 18%. Moreover, the pooled prevalence of *L. monocytogenes* in Iranian food samples was estimated at 4% (95% CI: 3–5%) ranging from 0 to 50%. From those 12 studies which reported the distribution of *L. monocytogenes* serotypes, it was concluded that 4b, 1/2a, and 1/2b were the most prevalent serotypes.

**Conclusions:** The prevalence of *L. monocytogenes* and prevalent serotypes in Iran are comparable with other parts of the world. Although the overall prevalence of human cross-contamination origin was low, awareness about the source of contamination is very important because of the higher incidence of infections in susceptible groups.

**Keywords:** *Listeria monocytogenes*, Food pathogen, Listeriosis, Meta-analysis, Iran

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**Background**

*Listeria* is ubiquitous Gram-positive bacteria, which are rod-shaped, facultative anaerobic, and non-spore forming, with a low C+G content [1]. The genus *Listeria* is composed of several species, of which *Listeria monocytogenes* is an opportunistic pathogen of humans and animals [1]. Due to ubiquitous nature of *Listeria* spp., and their unique ability to survive across a broad range of environmental stress including pH, temperature, and salt, they are considered as important foodborne pathogens [2].

*L. monocytogenes* as the main causative agent of human listeriosis is an intracellular bacterium that has the capability to infect a wide range of cell types and cross the intestinal, blood-brain and placental barriers [3]. Human listeriosis is a sporadic foodborne disease, which is epidemiologically linked with consumption of contaminated food products [4]. In human, listeriosis may range from a mild and self-limiting flu-like sickness or febrile gastroenteritis in healthy people to severe systemic infections including meningitis, septicemia, and abortion in susceptible people [3]. High-risk individuals are the pregnant women, neonates, elderly, immunocompromised...
individuals and adults with malignancy [5]. Listeriosis can be a serious disease with an approximate 20% mortality; that case–fatality rate may increase in groups at highest risk [4]. Regarding the wide distribution of L. monocytogenes in food resources and high fatality rate of listeriosis, L. monocytogenes has been considered as a major public health concern [1]. Variation in Iranian food tastes results in consumption of different kinds of foods, which may be considered as a risk factor of listeriosis outbreaks. Despite some local information on the prevalence of Listeria spp. in various food resources in Iran, there is no comprehensive data available on its prevalence to estimate the burden of L. monocytogenes. Therefore, this study aimed to investigate the prevalence of L. monocytogenes in food resources and human samples from Iran by using a systematic review and meta-analysis based method. This finding can provide good epidemiological background contributing to the international data of L. monocytogenes distribution.

Methods

Search strategies

A systematic literature search was conducted in the Web of Science, PubMed, Scopus and Google Scholar electronic databases from papers that were published by Iranian authors since January of 2000 to the end of April 2017. The following terms, “Listeriosis” or “Listeria” or “L. monocytogenes”, in combination with “Food”, “Animal”, “Human”, and “Iran” were searched as scientific keywords in the present survey both separately and simultaneously in March and April 2017.

Selection criteria and quality assessment

Two reviewers independently screened the databases with the related keywords and reviewed the titles, abstracts, and full texts to determine the articles which met the inclusion criteria; any discrepancies were resolved by consensus. The articles published in English or Persian language with English abstract which indexed in Pubmed or Scopus and had met the inclusion criteria were considered in our survey: standard methods (Culture methods, the results based on antibodies (ELISA) and molecular techniques) were used for Listeria detection, present data on the prevalence of L. monocytogenes, and samples were collected from foods or clinical samples. The criteria for identifying Iranian authors were the author or location of the work and also affiliations of authors. Additionally, research that has been conducted by non-Iranian authors on the Iranian population or samples were also assessed. Studies that did not use standardized methods, the sample size was less than 10 isolates, duplicate reports, and articles, samples obtained from environment sources or the origin of samples was unclear in them, articles that were written in Persian with Persian abstract and studies which did not detect L. monocytogenes were excluded. The quality of eligible studies was judged independently by two authors in accordance with the Joanna Briggs Institute. Eventually, the studies that obtained more than 60% were included in this study [6].

Data extraction

The following details were extracted for each of the included studies: the first author’s name, the time of performing the study, publication date, the study setting, sample size, source of isolation, the frequency of Listeria spp., and L. monocytogenes serotypes.

Statistical analysis

To estimate the overall prevalence meta-analyses, “metaprop program” in STATA version 14.0 (STATA, College Station, TX, USA) statistical software was used [7]. Meta-analysis was performed by using the random-effects model to estimate the pooled prevalence and corresponding 95% confidence interval (CI). Statistical heterogeneity groups were estimated using the Cochran Chi-square test and the Cochrane-I2. The funnel plot, Begg’s rank correlation test, and Egger’s weighted regression tests were used to evaluate possible publication bias (P < 0.05 was considered as an indication of a statistically significant publication bias). Possible sources of heterogeneity were evaluated by sensitivity analysis, meta-regression and subgroup analysis based on the location of the study and diagnostic methods [8, 9]. Sensitivity analysis was applied to determine that the exclusion of any study has a significant effect on the estimated pooled prevalence while ignoring each individual one. The present study designed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Additional file 1).

Results

The database search yielded 4990 citations. Among them, 4931 were removed by index, title and abstract screening and 59 were accessed in full text. Of 59 reviewed studies, three studies had a sample size less than 10 isolates, three studies did not report the prevalence of L. monocytogenes, two studies had a methodological problem, two studies collected samples from environment sources, and results of two studies were unclear. Finally, 47 studies matched with eligibility criteria and were subjected to meta-analysis, [2–4, 10–53]. However, out of 47 included studies, three studies reported prevalence in animals and/ humans and/food, simultaneously. The searching procedure for selection of eligible studies is demonstrated in Fig. 1.
The full results of the included articles, sample size, the prevalence of *L. monocytogenes* and predominant serotypes are presented in Table 1.

Eleven studies investigated the prevalence of *L. monocytogenes* in humans. From those studies, the pooled prevalence of *L. monocytogenes* was 10% (95% CI: 7–12%) ranging from 0 to 28% (Fig. 2). There was a significant heterogeneity among the 11 studies ($\chi^2 = 331.98; p < 0.001; I^2 = 97.2%$). The funnel plot for publication bias showed evidence of asymmetry. Additionally, Begg’s and Egger’s tests were performed to quantitatively evaluate the publication biases. According to the results of Begg’s test ($z = 1.48, p = 0.02$) and Egger’s test ($t = 5.21, p < 0.001$) a significant publication bias was observed.

According to the included publications, in nine studies the prevalence of *L. monocytogenes* was investigated in animals. The pooled prevalence of *L. monocytogenes* was estimated at 7% (95% CI: 4–10%) ranging from 1 to 18% (Fig. 3). There was a significant heterogeneity among the nine studies ($\chi^2 = 85.46; p < 0.001; I^2 = 90.64%$). The symmetric funnel plot showed no evidence of publication bias and confirmed by the results of Begg’s test ($z = 0.21, p = 0.835$) and Egger’s test ($t = 1.62, p = 0.116$).

We found 32 articles which investigated the prevalence of *L. monocytogenes* in foods samples. The pooled prevalence of *L. monocytogenes* in Iranian food samples was estimated at 4% (95% CI: 3–5%) ranging from 0 to 50% (Fig. 4). Based on Q statistic and the I² index heterogeneity was significant ($\chi^2 = 573.757; p < 0.001; I^2 = 94.97%$). There was evidence of strong publication bias from the funnel plot of the included articles (Fig. 5); it was confirmed by Begg’s rank correlation analysis ($z = 3.73, p < 0.001$). However, Egger’s regression analysis showed a significant publication bias ($t = 1.62, p = 0.116$).

Of the totally included articles, only in 12 studies the distribution of *L. monocytogenes* serotypes was reported. From those studies, it was concluded that 4b, 1/2a, and 1/2b were the most prevalent serotype. Furthermore, the pooled prevalence of *L. innocua* was 5.6% ranging from 4.1 to 7.7%.

The results of subgroup analysis based on geographic location in human samples showed that pooled prevalence of *L. monocytogenes* was 14% (95% CI: 1–36%; n = 3 studies), 10% (95% CI: 4–18%; n = 7 studies), and 1% (95% CI: 0–5%; n = 1 studies) in South, North (West and East) and West of Iran, respectively (Additional file 2: Figure S1). The results of subgroup analysis based on diagnostic methods in human samples showed that pooled prevalence of *L. monocytogenes* was 1% (95% CI: 0–3%; n = 3 studies), 26% (95% CI: 23–30%; n = 2 studies), and 11% (95% CI: 4–17%; n = 6 studies) based on culture, serology and PCR methods, respectively (Additional file 2: Figure S1).

The results of subgroup analysis based on geographic location in food samples showed that pooled prevalence of *L. monocytogenes* was 7% (95% CI: 4–10%; n = 13 studies), 4% (95% CI: 2–5%; n = 11 studies), and 2% (95% CI: 1–3%; n = 4 studies), 3% (95% CI: 3–4%; n = 2 studies) in North (West and East), Central, South and all parts of Iran, respectively (Additional file 2: Figure S1).

The results of subgroup analysis based on the diagnostic methods in food samples showed that pooled prevalence of *L. monocytogenes* was 3% (95% CI: 1–4%; n = 11 studies), 5% (95% CI: 3–6%; n = 19 studies), and 12% (95% CI: 9–14%; n = 1 studies), 2% (95% CI: 1–4%; n = 1 studies) based on culture, PCR, Real-Time PCR and culture and serology methods, respectively (Additional file 2: Figure S1).

The results of subgroup analysis based on geographic location in Animal samples showed that pooled prevalence of *L. monocytogenes* was 9% (95% CI: 5–13%; n = 5 studies), 2% (95% CI: 0–4%; n = 2 studies), and 7% (95% CI: 3–14%; n = 1 studies) in North (West and East), Central and South of Iran, respectively (Additional file 2: Figure S1). The results of subgroup analysis based on the diagnostic methods in Animal samples showed that pooled prevalence of *L. monocytogenes* was 10% (95% CI: 6–13%; n = 5 studies) and 3% (95% CI: 1–5%; n = 3 studies) based on PCR and methods, respectively (Additional file 2: Figure S1).
| Author          | Publication year | Years of study | City or Province/ Region | Diagnostic method | Types food/animal species/Human | Study design | Sample size | L. monocytogenes | Predominant serotypes | L. innocua | Total Ref |
|----------------|------------------|----------------|--------------------------|-------------------|--------------------------------|--------------|-------------|-----------------|-----------------------|------------|-----------|
| Firouzi et al. | 2000             | UN Shiraz/South| Culture                  | Human             | Slaughter houses               | Cross sectional | 130         | 0               | –                     | 0          | 3         |
| Akhondzadeh Basti et al. | 2004 | UN Tehran and Guilan/North | Culture | Food | Fresh fish, salted and smoked fish | Cross sectional | 120         | 4               | 4b                   | –          | 7         |
| Moshtaghi et al. | 2007             | UN Shahrekord/ Central | Culture | Food | Raw milk | Cross sectional | 500         | 8               | 4b                   | 3          | 11        |
| Rahimi et al. | 2008             | UN Isfahan/Central | Culture | Animal | Cattle | Cross sectional | 200         | 6               | –                     | –          | 9         |
| Jalali et al. | 2008             | UN Isfahan/ Central | PCR | Food | Meat, diary, vegetables products ready to eat food | Cross sectional | 461         | 7               | –                     | 13         | 27        |
| Jamshidi et al. | 2009             | UN Bandar Abbas/South | Serology | Human | Spontaneous abortion, control group | Case-control study | 450         | 124             | –                     | –          | 10        |
| Jami et al. | 2010             | UN Mashhad/ Northeast | PCR | Food | Raw milk | Cross sectional | 100         | 4               | –                     | –          | 11        |
| Rahimi et al. | 2010             | UN Isfahan/Central | PCR | Food | Milk/dairy products | Cross sectional | 594         | 18              | –                     | 32         | 55        |
| Mahmoodi et al. | 2010             | UN Noorabad/South | Culture | Food | Raw milk, White cheese, yoghurt | Cross sectional | 360         | 6               | –                     | –          | 13        |
| Lotfollahi et al. | 2011             | UN Tehran/North | Culture | Human | Spontaneous abortions | Cross sectional | 100         | 9               | –                     | –          | 14        |
| Rahimi et al. | 2011             | UN Tehran/North | Culture | Human | Pregnant mothers | Cross sectional | 512         | 5               | –                     | –          | 15        |
| Rahimi et al. | 2011             | UN Isfahan and Shahrekord/ Central | PCR | Food | Sea food | Cross sectional | 264         | 5               | –                     | 15         | 20        |
| Ghaseemian Safaei et al. | 2011             | UN Shahrekord/ Central | Culture | Food | Eggs | Cross sectional | 100         | 0               | –                     | –          | 17        |
| Goudarzi et al. | 2012             | UN Karaj/North | PCR | Human | Women with septic abortion | Cross sectional | 87          | 12              | –                     | –          | 18        |
| Fallah et al. | 2012             | UN Shahrekord/ Central | PCR | Food | Poultry product | Cross sectional | 402         | 52              | 4b, 1/2a, 1/2b, 1/2c | 62         | 134       |
| Zarei et al. | 2012             | UN Ahvaz/Southwest | PCR | Food | Raw/fresh/frozen, and ready-to-eat (RTE) seafood | Cross sectional | 245         | 2               | –                     | –          | 19        |
| Hosseinzadeh et al. | 2012             | UN Shiraz/South | PCR | Animal | Poultry flocks | Cross sectional | 100         | 7               | –                     | –          | 20        |
| Safarpoor Dehkordi et al. | 2012             | UN Various parts of Iran | Real-Time PCR | Food | Milk | Cross sectional | 596         | 69              | –                     | –          | 21        |
| Ranjbar and Halaji | 2012             | UN Ahvaz/Southwest | PCR | Animal | Vaginal swab/ Urine samples | Cross sectional | 1575        | 158             | –                     | –          | 20        |
| Author          | Publication year | Years of study | City or Province/Region | Diagnostic method | Sample source | Types food/animal species/Human | Study design | Sample size | L. monocytogenes | Predominant serotypes | L. innocua | Total Ref |
|-----------------|------------------|----------------|-------------------------|-------------------|---------------|-------------------------------|--------------|-------------|-----------------|------------------------|------------|-----------|
| Rahimi et al.   | 2012             | 2009–2010      | Chahar Mahal & Bakhtyari/Central and South | Culture and PCR  | Food           | Dairy products                | Cross sectional | 290         | 5               | –                      | 14         | 21        | 22       |
| Rahimi et al.   | 2012             | 2010–2011      | Various parts of Iran   | PCR               | Food           | Raw meats                     | Cross sectional | 1107        | 27              | –                      | 98         | 141       | 23       |
| Seifi et al.    | 2012             | 2009–2010      | North and west         | PCR               | Animal         | Broiler flocks                | Cross sectional | 490         | 44              | –                      | –          | –         | 24       |
| Fallah et al.   | 2013             | 2011–2012      | Shahrekord/ Central    | PCR               | Food           | Raw and RTE seafood product   | Cross sectional | 462         | 35              | 1/2a, 4b, 1/2c, 1/2b, 4c | –          | –         | 25       |
| Jamali et al.   | 2013a            | 2008–2010      | Tehran/North           | PCR               | Food           | Raw milk                      | Cross sectional | 446         | 18              | 1/2a, 3a; 1/2c, 3c, 4b, 4d, 4e | 48         | 83        | 26       |
| Jamali et al.   | 2013b            | 2008–2010      | Tehran/North           | PCR               | Food           | Milk                          | Cross sectional | 207         | 17              | (4b, 4d or 4e), (1/2a or 3a), (1/2b, 3b or 7), (1/2c or 3c) | 3          | 21        | 27       |
| Sohrabi et al.  | 2013             | UN             | Isfahan/Central        | Culture           | Food           | Poultry meat                  | Cross sectional | 52          | 1               | –                      | 11         | 12        | 28       |
| Vahedi et al.   | 2013             | 2011           | Sari/North             | Culture           | Food           | Milk                          | Cross sectional | 200         | 0               | –                      | –          | –         | 29       |
| Momtaz et al.   | 2013             | 2010–2011      | Isfahan and Shahrekord/ Central | PCR               | Food           | Fresh fish/shrimp samples     | Cross sectional | 300         | 18              | 4b, 1/2b, 1/2a | 2          | 24        | 30       |
| Salehian et al. | 2013             | 2012           | Sari/North             | Culture           | Food           | Traditional ice cream         | Cross sectional | 50          | 1               | –                      | –          | –         | 31       |
| Zarei et al.    | 2013             | UN             | Ahvaz/Southwest       | PCR               | Food           | Beef, buffalo and lamb meats  | Cross sectional | 210         | 7               | –                      | –          | –         | 32       |
| Akya et al.     | 2013             | UN             | Kermanshah/West       | Culture           | Food           | Dairy, meat products, RTE     | Cross sectional | 530         | 3               | –                      | 56         | 66        | 33       |
| Shakib et al.   | 2013             | UN             | Lorestan/West          | PCR               | Human          | Pregnant women                | Cross sectional | 100         | 0               | –                      | –          | –         | 34       |
| Rahimi et al.   | 2014             | 2010–2011      | Fars and Khuzestan/South and Southwest | PCR               | Food           | Bulk milk, camel, Water, buffalo, ovine, caprine, | Cross sectional | 260         | 7               | –                      | 13         | 27        | 3        |
| Esami et al.    | 2014             | 2012–2013      | Tehran/North           | PCR               | Human          | Women with abortion           | Cross sectional | 96          | 16              | –                      | –          | –         | 35       |
| Aldoosti et al. | 2014             | 2012           | Isfahan/Central       | Culture           | Animal         | Domestic dogs                 | Cross sectional | 92          | 1               | 1/2b                   | –          | –         | 36       |
| Jamali et al.   | 2014             | 2008–2010      | Tehran/North           | Culture           | Animal         | Duck, goose intestinal contents | Cross sectional | 471         | 19              | –                      | 5          | 58        | 37       |
| Moosavy et al.  | 2014             | UN             | Tabriz/Northwest      | Culture           | Food           | Raw milk                      | Cross sectional | 18          | 9               | –                      | –          | –         | 38       |
| Haghi et al.    | 2015             | 2014           | Zanjan/West            | PCR               | Food           | Bovine milk, ovine milk       | Cross sectional | 60          | 0               | –                      | –          | –         | 39       |
| Author                  | Publication year | Years of study | City or Province/Region | Diagnostic method | Sample source | Types food/animal species/Human                                      | Study design    | Sample size | L. monocytogenes | Predominant serotypes | L. innocua | Total Ref |
|-------------------------|------------------|----------------|-------------------------|-------------------|---------------|--------------------------------------------------------------------|----------------|--------------|---------------------|--------------------------|-----------|-----------|
| Haghroosta et al.       | 2015             | 2015           | UN Ahvaz/Southwest      | Serologic         | Human         | Pregnant women with spontaneous abortion and healthy pregnant women | Cross sectional| 180          | 43                  | –                        | –         | 40        |
| Jamali et al.           | 2015             | 2012–2014      | Mazandaran/North        | PCR               | Food          | Raw fish                                                           | Cross sectional| 488          | 104                 | 1/2a, 4b, 1/2b             | 34        | 37        | 41        |
| Soltan Dallal et al.    | 2015             | 2013           | Tehran/North            | Culture           | Food          | Vegetables, salads                                                 | Cross sectional| 200          | 1                   | –                        | –         | 48        | 42        |
| Mashak et al.           | 2015             | 2011–2012      | Tehran/North            | Culture           | Food          | Fresh, frozen meats                                                | Cross sectional| 410          | 115                 | 1/2a, 4b, 4c, 3b           | –         | 43        |
| Mansouri-Najand et al.  | 2015             | 2011           | Kerman/Central          | PCR               | Food          | Raw milk                                                           | Cross sectional| 100          | 5                   | –                        | –         | 44        |
| Pourkaveh et al.        | 2016             | 2015           | Tehran/North            | PCR               | Human         | Women with spontaneous abortion                                    | Cross sectional| 317          | 54                  | –                        | –         | 45        |
| Abdollahzadeh et al.    | 2016             | 2014–2015      | Karaj and Tehran/North  | PCR               | Food          | Fish, shrimp, RTE seafood                                         | Cross sectional| 201          | 5                   | 1/2a, 3b, 7, 1/2a, 3a     | –         | 18        | 46        |
| Pournajaf et al.        | 2016             | 2012–2015      | Tehran/North            | PCR               | Human         | Patients with spontaneous abortions                               | Cross sectional| 170          | 14                  | –                        | –         | 47        |
| Zeinali et al.          | 2017             | 2013           | Mashhad/North east      | PCR               | Animal        | Domestic animals                                                    | Cross sectional| 317          | 20                  | –                        | 12        | 80        | 48        |
| Lotfollahi et al.       | 2017             | 2013–2015      | Tabriz/North west       | PCR               | Animal        | Fresh chicken carcasses                                            | Cross sectional| 267          | 8                   | 1/2c or 3c, 4b, 4d or 4e, 1/2a or 3a | –         | 49        |
**Fig. 2** Forest plot of the meta-analysis of *L. monocytogenes* prevalence in human

**Fig. 3** Forest plot of the meta-analysis of *L. monocytogenes* prevalence in animals
Sensitivity analysis and meta-regression

The sample size of included studies could not be accounted as the causes of heterogeneity due to the result of carried meta-regression analysis in which no possible associated effect was observed between a sample size of included studies and pooled prevalence.

Besides, sensitivity analysis’s results concluded that none of the incorporated studies has the ability to change the overall prevalence substantially (Additional file 3: Figure S2).

Discussion

Direct transmission of *L. monocytogenes* from the infected animals or contaminated raw products is the main route of human cross-contamination [54]. The unique ability of this microorganism to survive food preservation or hostile environments and the presence of numerous bacterial surface components and extracellular virulence factors make *L. monocytogenes* as a serious threat to food safety [1, 55]. To the best of our knowledge, this study is the first...
comprehensive systematic review of the prevalence of *L. monocytogenes* in foods, animal and human origin from Iran, simultaneously. Based on the meta-analysis results, the overall estimate of *L. monocytogenes* prevalence among human origin with 10% was slightly higher than animal and food resources, i.e. 7% and 4%, respectively. However, some reasons may explain the higher prevalence of *L. monocytogenes* in Iranian population compared to environmental sources. First, most of the human origin studies were performed on susceptible groups including pregnant women or hospitalized patients, so the burden of *L. monocytogenes* infections would be expected to be lower in the general community. Second, in two studies with the highest isolation rate, authors used the serological method for detection of *L. monocytogenes* among the participants [14, 44] because antigenic cross-reactivity serological methods have lower discriminatory power in epidemiological studies compared to molecular methods [56].

Due to the multifactorial nature of *L. monocytogenes* prevalence, its international comparison is challenging. It seems that some factors have more profound effects on the prevalence of *L. monocytogenes*. Regarding the role of sample type, with some variation incidence of *L. monocytogenes* contamination in dairy products tends to be lower than other resources such as vegetables or meat products (mostly less than 10%) [57–64]. Based on previous reports, the infection rate of domestic and wild animals is frequently higher than foods origin and has a much more variation [65–71].

Gain a global estimate of *L. monocytogenes* infections in human is even more challenging since most of the studies looking in the distinct range of society or samples [72–78]. Besides the variation according to the origin of isolation, various incidence rates of *L. monocytogenes* may arise from differences in the sample size, seasonal variability, and geographical distribution.

*Listeria innocua* is a ubiquitous non-pathogenic membrane of genus *Listeria*. This bacterium does not seem to carry the virulence-associated genes described in pathogenic species [79]. However, recently it has been shown that *L. innocua* can invade bovine trophoblasts, but it is unable to multiply in the intracellular environment [80]. In our findings the isolation rate of *L. innocua* among Iranian food resources was remarkable. To date, there is no report of human complication by this bacterium from Iran; however, two cases of *L. innocua* human infections were reported in European countries [79, 81]. These observations make us keep in mind that we should not rule out the potential risk of *Listeria* contamination rather than *L. monocytogenes*.

Analysis of the included studies revealed serotypes 4b, 1/2a, and 1/2b as the most prevalent serotypes. From annual trends of serotypes changes, it seems that 4b serotype is losing its dominant position and replaced by 1/2a and 1/2b. However, serotypes can be variable during different time periods, seasons or geographical distributions, and different sample type. Wang et al. showed 648 food samples collected within years 2013–2014 in Shanghai, China the majority of the isolates (more than 80%) belonged to serotypes 1/2a, and 1/2b [58]. Kevenk et al. from Turkey reported the presence of four different serotypes (1/2a, 1/2b, 1/2c, and 4b) in isolates obtained from milk and dairy products [61]. Haley et al. showed the predominance of 3 serogroups (1/2a, 1/2b, and 4b) in the isolates collected during 2004 and 2010 within a U.S. dairy herd [82]. In a study on several regions of Brazil from 1975 to 2013, with the same serotype distribution, Almeida and colleagues introduced 4b, 1/2b, and 1/2c, as the main serotypes in human and food sources [83]. Serotypes 1/2a, 1/2b, and 4b were the most prevalent serotypes in sows and fattening pigs in France in 2008 [70]. Hasegawa et al. showed the predominance of 1/2b, 1/2a, and 4b serotypes among black beef cattle in Japan [68]. Surveillance of invasive listeriosis within the years 2006–2010 in Italy, revealed serotypes 1/2a, 4b, and 1/2b as the frequent types [84]. When rank correlation methods show bias, the bias is likely evidence of small studies effect [85]. Meanwhile, meta-regression analysis showed that weight of studies could not be considered as a confounding factor. Also, sensitivity analysis on included studies indicated that exclusion of any study has no significant effect on the estimated pooled prevalence.

The limitations of our systematic review include the following: Firstly, due to the extent of *L. monocytogenes* has not yet been examined in many regions of Iran, we cannot fully represent the frequency of *L. monocytogenes* in the country. Secondly, the studies could not fully indicate the prevalence of *L. innocua* in Iran, because the prevalence of *L. innocua* has not yet been surveyed in many studies conducted in Iran. Third, heterogeneity was detected among the included studies therefore, the results should be interpreted with caution.

**Conclusions**

The results of the present study provide good epidemiological information about the contamination status and distribution of *L. monocytogenes* among Iranian resources. The prevalence of *L. monocytogenes* and prevalent serotypes in Iran is comparable with other parts of the world. Although the overall prevalence of human cross-contamination source was low, awareness about the source of contamination is very important because of a higher incidence of infections in susceptible groups.
Additional files

**Additional file 1:** Study design according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. (DOC 57 kb)

**Additional file 2:** Figure S1. Forest plot of pooled estimated prevalence of *L. monocytogenes* in subgroup analysis based on geographic location and diagnostic methods in Human (1), Food (2) and Animal samples (3). (ZIP 7589 kb)

**Additional file 3:** Figure S2. Sensitivity plot of studies included in the systematic review and meta-analysis related to (a) Human, (b) Animal, and (c) Food. (ZIP 248 kb)

**Abbreviations**

CI: Confidence interval; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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**Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Authors’ contributions**

RR conceived designed and supervised the study and revised the manuscript. Both authors read and approved the final manuscript.

**Ethics approval and consent to participate**

Not applicable.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

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