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Communicable diseases as health risks at mass gatherings other than Hajj: what is the evidence?

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SUMMARY

Mass gatherings are characterized by the concentration of people temporally and spatially, and may lead to the emergence of infectious diseases due to enhanced transmission between attendees. This is well-demonstrated in the context of the Hajj and Umrah pilgrimages in Saudi Arabia. The goal of this review was to present the available evidence on outbreaks associated with a variety of pathogens, or also the lack thereof, as assessed by thorough surveillance at any mass gatherings with the exception of those in Saudi Arabia. A systematic search for relevant articles in the literature was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Sixty-eight studies were identified. Although outbreaks have not been reported frequently in or after mass gatherings outside the Hajj and Umrah pilgrimages, they have sometimes occurred at Muslim, Christian, and Hindu religious events, at sports events, and at large-scale open air festivals. In this review it was found that the most common outbreaks at these mass gatherings involved vaccine preventable diseases, mainly measles and influenza, but also mumps and hepatitis A. Meningococcal disease has rarely been recorded. Additionally it was found that the transmission of various communicable diseases that may not be prevented by vaccination has been recorded in association with mass gatherings. These were mainly gastrointestinal infections, caused by a variety of pathogens. It was also noted that some outbreaks occurring at mass gatherings have resulted in the international spread of communicable diseases.

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1. Introduction

Mass gatherings are characterized by the concentration of people at a specific location for a specific purpose over a set period of time and which have the potential to strain the planning and response resources of the country or community.¹ These gatherings might be planned or unplanned and recurrent or sporadic. The number of attendees may vary from hundreds to millions. Large religious events like the Hajj Muslim pilgrimage gather two to three million people in Saudi Arabia annually, while the Kumbh Mela in India is attended by up to 40 million worshippers. Around 8.8 million tickets were sold for the London Olympic Games in 2012 and over three million people attended the 2014 FIFA World Cup in Brazil. Attendance at the top 20 European music festivals and street parades ranges from 17 000 to one million in a single

day. Most mass gatherings are characterized not only by a large attendance, but also by crowding. There may be poor sanitary conditions at some mass gatherings, and at some events there may be promiscuity.

Large-scale sports events are usually well-organized by highly specialized teams of staff and are often organized in the setting of large cities. The legacy of events such as the Olympics includes improvements in infrastructure, economic benefits for various sectors, and improved surveillance. A characteristic of large-scale open air festivals, including music festivals, may be that they are not always organized and managed by professionals and may involve inexperienced volunteers as staff members. Music festivals in particular have specific characteristics, including an outdoor setting, on-site housing and food supplies, participants of a young age, recreational motivations, and the potential for excessive alcohol and/or drug consumption.

At such mass gatherings, the concentration of people temporally and spatially may lead to the emergence of infectious diseases due to enhanced transmission between attendees. The annual Hajj and Umrah pilgrimages in Saudi Arabia are the mass gatherings at

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which communicable diseases have been most closely assessed. Meningitis outbreaks, respiratory tract infections, and the transmission of infectious diarrhoea have been described extensively.^{2–4} However, many other mass gatherings take place in various parts of the world, some also religious, others athletic, socio-cultural, or commercial, and some are very spontaneous, such as funerals or political rallies. The goal of this review was to present the available evidence on outbreaks associated with a variety of pathogens, or also the lack thereof, as assessed by thorough surveillance at any mass gatherings with the exception of those in Saudi Arabia.

2. Methods

2.1. Search strategy and selection criteria

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (<http://www.prisma-statement.org>). The following databases were searched, attempting to identify all relevant studies published from January 1980 to January 2016: Scopus (<http://www.scopus.com/>), PubMed (<http://www.ncbi.nlm.nih.gov/pubmed>), and Google Scholar (<http://scholar.google.fr/>). The most recent search was conducted on January 18, 2016. The topic search terms used for searching the databases were the following:

- #1: “mass gathering” OR “mass gatherings” OR “pilgrimage” OR “festival”; OR “sport” OR “Olympics” OR “FIFA” OR “EURO”
- #2: “outbreak” OR “infection” OR “infectious diseases”
- #3: #1 AND #2

Only articles published in English were included, based on the common language of the authors. For inclusion, an article had to fulfil the following criteria: (1) be related to a mass gathering, (2) report outbreaks, and (3) report the pathogen responsible for the

outbreak when possible. Case reports were excluded. The reference lists of reviews were screened to identify studies possibly missed in the search.

Both researchers independently performed the screening of the abstracts. Any discordant result was discussed in a consensus meeting. After screening the abstracts, the full texts of the articles were assessed for eligibility by the same two researchers and selected or rejected for inclusion in the systematic review.

2.2. Data collection process

The following data (if available) were extracted from each article: year, place of event, number of attendees, syndromic classification of outbreaks, pathogen responsible, and number of cases. A distinction was made between outbreaks occurring at religious meetings, sports events, and large-scale open air festivals because of the distinct characteristics of these mass gatherings.

2.3. Data synthesis and analysis

As a result of the nature of the studies and the heterogeneity in patient populations, a formal meta-analysis was not possible. Therefore, the study results were summarized to describe the main outcomes of interest (i.e., the occurrence of outbreaks at mass gatherings other than Hajj and Umrah). If possible, percentages not presented in the articles were calculated from the available data.

3. Results and discussion

3.1. Study selection

A total of 257 articles were identified in the database search and seven additional articles were found through the manual search. After screening the titles and abstracts, 68 articles were eventually retained for full-text assessment. All 68 articles were included in the qualitative synthesis of the systematic review (Figure 1).

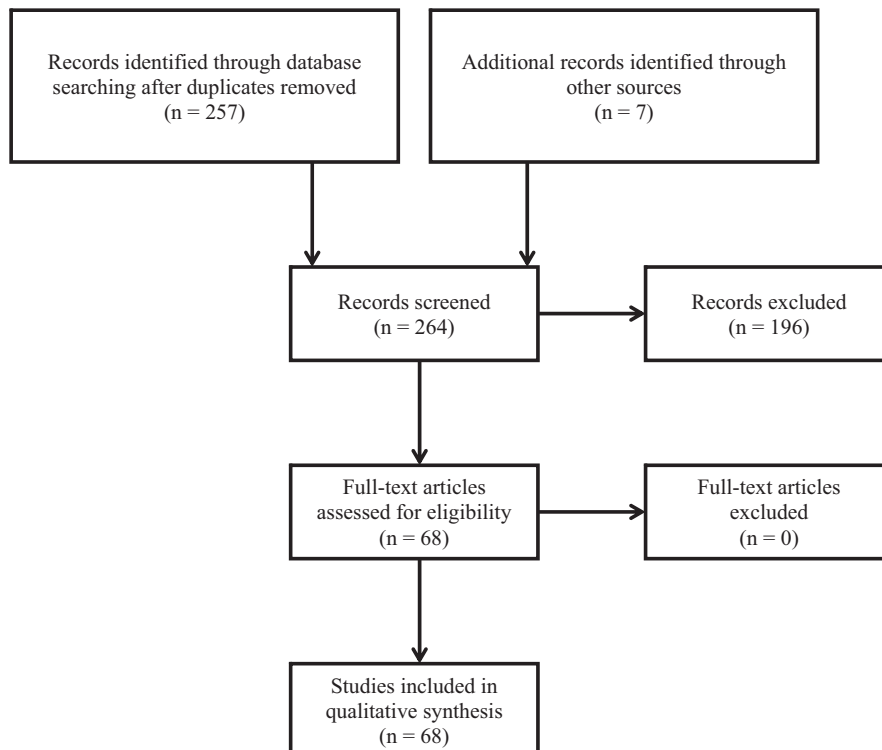


Figure 1. Flow diagram of the search strategy.

3.2. Study characteristics

A total of 24 studies reported outbreaks at religious meetings (Muslim events outside the Hajj and Umrah and Christian and Hindu events), 17 reported outbreaks or an absence of outbreaks at sports events (Summer and Winter Olympics, FIFA and EURO football cups, and a few smaller events), and the remaining 27 studies reported on large-scale open air festivals.

3.3. Religious meetings

An increased prevalence of infectious diseases has been described at Muslim pilgrimages other than Hajj and Umrah, such as the annual celebration of the day of Ashura in Karbala, Iraq, which is attended by three to four million Muslims from within and outside Iraq. In 2010, a febrile illness seen in the emergency ward of Karbala hospital was recorded seven times more often during the event as compared to before the event, in relation to an eight-fold increase in the population in the area during the event.⁵ Also in 2010, at the annual celebration of the Urs of Baba Farid in Pakpattan, Pakistan, attended by an estimated 500 000 people, the prevalence of acute respiratory illness showed a 25-fold increase and the prevalence of diarrhoea increased by a factor of 14, while the population increased by a factor of 3.⁶ During Moulay Abdellah Amghar Moussem in 2009 and 2010, an 8-day annual gathering attracting over 360 000 people in Morocco, gastrointestinal disorders recorded at the health care centre increased significantly from 11% to 14% of all hospital visits during the event.⁷ Finally, during the 2010 Eid al-Adha in Jordan, gathering up to 70 000 people, there was a 33% increase in overall hospital admissions during the event, while the population increased by a factor of 2 during that period.⁸ The information provided in these reports was based on syndromic surveillance data; no reliable information was provided on which assessments of outbreaks occurring at these events could be made, in contrast to the Hajj in Saudi Arabia.

Evidence of outbreaks is not limited to Muslim gatherings; they also occur at Christian mass gatherings (Table 1). Respiratory tract

infections due to influenza were recorded during World Youth Day 2008 in Australia,⁹ subsequently resulting in a number of publications.^{10–15} No report of other outbreaks at subsequent World Youth Days in Madrid (2011) and Rio (2013) could be found. Another influenza outbreak was recorded during the Itzapalapa Passion Play celebration in Mexico in 2009.^{16,17} A measles outbreak occurred at a church gathering in the USA in 2005 among unvaccinated participants,¹⁸ and another was recorded during the 2010 Taizé festival in France, affecting several dozen mainly unvaccinated subjects, including secondary and tertiary cases mainly in Germany.¹⁹ An outbreak of mumps with 214 identified patients occurred after an Easter festival in Austria in 2006.²⁰ Gastrointestinal infection associated with *Salmonella enterica* was reported from a Church festival in the USA in 2010, which was linked to the consumption of pulled pork.²¹ Furthermore, norovirus was reported in relation to the Lourdes pilgrimage in France in 2002 and 2008, with secondary cases in Swiss and Dutch nursing homes and cases in Ireland.^{22,23}

Interestingly, most of these outbreaks involved not only international participants, but also numerous secondary cases through the participants spreading the illness upon return to their country of origin.

Lastly, the Kumbh Mela in India is the largest congregation of pilgrims worldwide; 40 million are expected to visit the next Mela in 2016. The vast majority of these pilgrims come from India, but there is increasing interest from the global population to bathe in the Ganges River among the crowds. Despite the size of the event, only recently has there been an increase in public health interest in relation to communicable diseases at the Mela.²⁴ Previously there had been only a few reports, e.g., on the cholera epidemics at the Mela in 1948²⁵ and as early as 1867, resulting in almost one million lives lost.²⁶ A syndromic survey conducted during the 2013 Mela evidenced a peak in diarrhoeal diseases and upper respiratory tract infection symptoms just after the bathing day.²⁷ Of 412 703 patients who attended the outpatient departments of hospitals, respiratory infections accounted for 70% of illnesses, while diarrheal diseases accounted for 5%. A hospitalization rate of 1.1% was recorded.²⁸

Table 1
Outbreaks at Christian mass gathering events

Event, place, year	Cumulated number of attendees	Syndromic classification (pathogen involved)	Case numbers	Estimated incidence per 100 000 attendees	Indication of patient age	Source of outbreak for gastrointestinal diseases	Ref.
Lourdes pilgrimage, France, 2002	>5 million	Gastrointestinal (norovirus)	>450 including >380 secondary cases	ND	Elderly residents and nursing staff	ND	22
Church gathering, USA, 2005	500	Respiratory (measles virus)	34	6800	88% of patients <20 years	–	18
Easter youth festival, Austria, 2006	ND	Respiratory (mumps virus)	214	ND	Age range of 80% of patients: 16–30 years	–	20
World Youth Day, Australia, 2008	500 000	Respiratory (influenza virus A and B)	100	20	Median age 21 years	–	9–15
Lourdes pilgrimage, France, 2008	8 million	Gastrointestinal (norovirus)	>190 including >100 secondary cases	ND	Elderly residents and nursing staff	ND	23
Itzapalapa Passion Play, Mexico, 2009	>2 million	Respiratory (influenza A(H1N1)pdm09 virus)	38	2	Age range of 32% of patients: 5–19 years; age range of 28%: 20–29 years	–	16,17
Taizé meeting, France, 2010	3500	Respiratory (measles virus)	27 (13 primary, 17 secondary, 7 tertiary cases)	371	Median age: 17 years for primary cases, 15 years for secondary cases, 13 years for tertiary cases	–	19
Church festival, USA, 2010	9000	Gastrointestinal (<i>Salmonella enterica</i> serotype Typhimurium)	64	711	Median age: 44 years	Pulled pork	21

ND, not documented.

3.4. Sports events

Zieliński published an excellent review on infectious diseases at mass gatherings,²⁹ including the Summer and Winter Olympics in Los Angeles (1984), Seoul (1988), Calgary (1988), Barcelona (1992), Albertville (1992), Lillehammer (1994), Atlanta (1996), Nagano (1998), Sydney (2000), Salt Lake City (2002), Athens (2004), Torino (2006), and Beijing (2008), the FIFA World Cup in France (1998), Korea and Japan (2002), and Germany (2006), and the EURO football cup in Belgium and Holland (2000), Portugal (2004), and Austria and Switzerland (2008). The author concluded that there is a lack of convincing evidence that large international sports events substantially increase the risk of outbreaks of infectious diseases. A single example of such an outbreak at these events was found, involving 36 individuals participating in the Winter Olympiad in Salt Lake City (2002) who tested positive for influenza among 188 individuals presenting with an influenza-like illness.³⁰

When reviewing the surveillance reports, no evidence was found of outbreaks of infectious diseases during subsequent Olympic Games in Vancouver (2010), London (2012), and Sochi (2014), during the FIFA World Cup in South Africa (2010) and Brazil (2014), or during the EURO football cup in Poland and Ukraine (2012).^{31–38} There was no indication of an increase in attendances at sexual health clinics in connection with the London Games in 2012.³⁹ Despite concerns about the quality of water in the Rio de Janeiro area, only a small outbreak of gastrointestinal illness occurred in a single team during the pre-race sailing competition in August 2015, but that appeared to be associated with the consumption of food from a street vendor close to a football stadium rather than from exposure to polluted water (Dr N. Nikolic, personal communication).

Special Olympic World Games are reserved for athletes with disabilities. After the Minneapolis gathering in 1991 a small outbreak of measles was recorded involving not only athletes, but also volunteers and a few spectators, most of whom had not been previously vaccinated.⁴⁰ Another small measles outbreak occurred subsequent to an international youth sporting event in Pennsylvania in 2007, and again the majority had previously received no or only one dose of vaccine.⁴¹ Only a single outbreak of meningococcal disease was found, and this involved four spectators at a rugby match.⁴² Lastly, there was a recent multinational Salmonella outbreak at an ice hockey competition in Latvia in 2015⁴³ (Table 2).

Infectious disease outbreaks have also been reported in competitive sports events that do not qualify as mass gatherings because of the small numbers of participants, or because of the environmental conditions (i.e., larger numbers of participants engaged in sports challenges in natural conditions, like triathletes

swimming in contaminated waters, participants in the Eco-Challenge-Sabah 2000 multisport endurance race held in Malaysian Borneo, participants in an adventure race in South Africa, or trekkers in Sweden where outbreaks of leptospirosis, rickettsial disease, and hepatitis B resulted from exposure to environmental factors).^{44,45}

3.5. Large-scale open air festivals

Large-scale open air festivals have specific characteristics, including an outdoor setting, on-site housing and food supplies, and the generally young age of participants.⁴⁶ Large-scale open air festivals include music festivals and other art festivals, sometimes including camping, street parades, village festivals, cultural festivals, university events, and large weddings. In the past many of these were not organized and managed by experienced professionals. Most music festivals take place over a 3- to 4-day period with an attendance ranging from 17 000 to 175 000 participants per day. The Zurich Street Parade, the largest worldwide in 2015 and lasting a single day, was attended by 1 million people.

Modern music festivals, street parades, and similar events are often associated with excessive alcohol and/or drug consumption, which may increase the risk of sexually transmitted infections (STIs).⁴⁷ Contrary to common belief, however, there is little evidence of an increase in STIs, as exemplified by studies on a music festival in Australia and the Carnival in the Rio de Janeiro area.^{48,49} Outbreaks at large-scale open air festivals have been described (Table 3) and have included food and waterborne infections caused by *Cryptosporidium parvum*, *Campylobacter spp*, *Escherichia coli*, *Salmonella enterica*, *Shigella sonnei*, *Staphylococcus aureus*, hepatitis A virus, and norovirus. Person-to-person transmission of influenza, measles, and mumps viruses has also been recorded.^{50–66} Faecal–oral and person-to-person transmissions of pathogens have resulted from non-compliance with basic hygiene rules, inadequate sanitation, and insufficient vaccination coverage.

Very recently, two EU countries, the UK and Sweden, have reported eight cases of invasive meningococcal disease due to serogroup W *Neisseria meningitidis* in scouts and their contacts associated with the 23rd World Scout Jamboree held in Yamaguchi City in Japan.⁶⁷ Finally, a measles outbreak was recorded following an international dog show in Slovenia in 2014, with about half of the patients having been infected there and the other half being secondary or tertiary cases. This outbreak also resulted in a chain of transmission in Italy.^{68,69} Global attention was gained by another multistate outbreak of measles originating at the Disney theme parks in California, USA.^{70,71}

Table 2
Outbreaks at mass gathering sport events

Event, place, year	Cumulated number of attendees	Syndromic classification (pathogen involved)	Case numbers	Estimated incidence per 100 000 attendees	Indication of patient age	Source of outbreak for gastrointestinal diseases	Ref.
International Special Olympics, USA, 1991	200 000	Respiratory (measles virus)	25	13	Median age: 21 years	–	40
Winter Olympiad, USA, 2002	ND	Respiratory (influenza)	36	ND	Mean age: 32 years	–	30
International youth sporting event, USA, 2007	265 000	Respiratory (measles virus)	7	3	Various	–	41
International youth ice hockey competition, Latvia, 2015	5000	Gastrointestinal (<i>Salmonella enteritidis</i> serogroup D)	214	4280	Median age: 13 years	ND	43
Rugby competition	7602	Neurological (<i>Neisseria meningitidis</i> serogroup C)	4	53	50–69 years	–	42

ND, not documented.

Table 3
Outbreaks at large-scale open air festivals

Event, place, year	Cumulated number of attendees	Syndromic classification (pathogen involved)	Case numbers	Estimated incidence per 100 000 attendees	Indication of patient age	Source of outbreak for gastrointestinal diseases	Ref.
Annual meeting Rainbow Family, USA, 1987	12 700	Gastrointestinal (<i>Shigella sonnei</i>)	>7000	55 118	Mean age: 27 years	Inadequate sanitation	50
Michigan Women's music festival, USA, 1988	6403	Gastrointestinal (<i>Shigella sonnei</i>)	3357	45 244	Mean age: 31 years	Tofu salad	51
Glastonbury music festival, UK, 1992	70 000	Gastrointestinal (<i>Campylobacter</i>)	72	103	Age range of the majority of patients: 20–30 years	Unpasteurized milk	52
Glastonbury music festival, UK, 1997	80 000	Gastrointestinal (<i>Escherichia coli</i> O157)	7	9	Mean age: 21 years	Mud contaminated by cattle faeces	53
Lunchtime concert, UK, 1999	1229	Gastrointestinal (norovirus)	>300	24 410	Primary school students	Vomit inappropriately cleaned	54
Ukrainian dance festival, Canada, 2001	>870	Gastrointestinal (<i>Cryptosporidium parvum</i>)	59	13 111	Mean age: 23 years	Swimming pool	55
San Juan festival, Spain, 2002	ND	Gastrointestinal (<i>Salmonella enterica</i>)	1435	ND	Age range of 24% of patients: 1–24 years; age range of 35%: 24–44 years	Pastry	56
Youth camp, Australia, 2003	350	Gastrointestinal (hepatitis A virus)	21	6000	Median age: 16 years	Coleslaw	57
Outdoor concert 'jam band', USA, 2003	82 000	Gastrointestinal (hepatitis A virus)	25	31–2083	Median age: 23 years	Unknown	58
Nagoya University festival, Japan, 2008	50 000	Gastrointestinal (<i>Staphylococcus aureus</i>)	75	150	ND	Crepes	59
Annual village festival, Spain, 2006	>4500	Respiratory (mumps virus)	77	422	Age range: 18–37 years	–	60
Rock Werchter music festival, Belgium, 2009	113 000	Respiratory (influenza A(H1N1)pdm09 virus)	14	12	Mean age: 23 years	–	61
Sziget music festival, Hungary, 2009	390 000	Respiratory (influenza A(H1N1)pdm09 virus)	8	2	Mean age: 21 years	–	62
Exit music festival, Serbia, 2009	165 000	Respiratory (influenza A(H1N1)pdm09)	49	30	Age range of 42% of patients: 20–29 years	–	63
Wedding, Spain, 2010	ND	Respiratory (measles virus)	83	ND	97% patients >16 years	–	64
Music festival, Germany, 2011	50 000	Respiratory (measles virus)	10	20	Median age: 19 years	–	65
Traditional festival, Japan, 2012	ND	Gastrointestinal (<i>Escherichia coli</i> O169:H41)	102	ND	Median age: 35 years	Inadequate sanitation	66
Scout Jamboree, Japan, 2015	33 000	Neurological (<i>Neisseria meningitidis</i> serogroup W)	8	24	Teenagers	–	67
International dog show, Slovenia, 2014	1100	Respiratory (measles virus)	63, including 30 secondary and tertiary cases	5727	5 children under 11 years; 39 adults aged 27–56 years (Slovenian cases) Median age: 31 years (Italian cases)	–	68,69
Disney theme parks (Anaheim), California, USA, 2014–2015	17 million (annual attendance), 65 000 per day	Respiratory (measles virus)	125, including 34 secondary cases	1	Median age: 22 years	–	70,71

ND, not documented.

3.6. Conclusions

This review has several limitations. It was limited to papers written in English, which may have been a source of bias. There was an important heterogeneity in studies in relation to study populations, clinical criteria for syndromic surveillance, and diagnostic methods applied. It is likely that a number of outbreaks were reported in local public health bulletins that are not indexed in Scopus, PubMed, or Google Scholar.

Although outbreaks are not frequently reported in or after mass gatherings outside the Hajj and Umrah pilgrimages, they do sometimes occur at Muslim, Christian, and Hindu religious events, at sports events, and at large-scale open air festivals. A total of 15 outbreaks of gastrointestinal infections associated with faecal-oral transmission in the context of mass gatherings were retrieved, which resulted from non-compliance with hygiene rules and inadequate sanitation. Most of these outbreaks were observed among adult participants, including elderly participants. In some

outbreaks, the attack rate was close to 50% of attendees.^{50,51} Overall, the estimated incidence of gastrointestinal diseases per 100 000 attendees ranged from nine to more than 55 000 during the outbreaks included in this review. A total of 16 outbreaks of respiratory infection and two outbreaks of meningitis associated with respiratory transmission in the context of mass gatherings were retrieved. The majority of these outbreaks affected children and young adults. Overall, the estimated incidence of confirmed respiratory infection per 100 000 attendees ranged from one to 6800 during the outbreaks included in this review. It was found that the most common outbreaks at mass gatherings involved vaccine preventable diseases, mainly measles and influenza, but also mumps and hepatitis A. Meningococcal disease has rarely been recorded. No account of tetanus or rabies was found; warnings were issued in respect to these prior to the FIFA World Cup in Brazil.⁷² It should be noted that visitors attending mass sporting events in urban areas faced fewer risks than those visiting for an extended stay in rural areas, particularly in the Amazon

basin. There may be an unexpected gap between forecasts and reality, as seen in relation to the dengue risk at the FIFA World Cup in Brazil in 2014. Attack rates of up to 300 dengue cases per 100 000 visitors were predicted by some experts when in fact only three cases of dengue were confirmed during the 2014 FIFA World Cup, affecting one Japanese citizen and two US citizens. This is likely because the World Cup took place during the dry season in Brazil, which is associated with a very low residual risk of dengue.⁷³ There might be misperceptions when basing the risk assessment on the recorded incidence of a disease in the local population or even in international travellers if seasonality patterns are neglected.

Furthermore, the transmission of various communicable diseases that may not be prevented by vaccination was also found to have been recorded in association with mass gatherings. These were mainly gastrointestinal infections due to a variety of pathogens.

It was noted that many outbreaks occurring at mass gatherings resulted in the international spread of communicable diseases. This was best exemplified by a measles outbreak with the index cases infected during two concurrent sports events in Rimini, Italy (the 16th Italia Super Cup, an international youth football tournament, and the World Association of Kickboxing Organizations (WAKO) Bestfighter World Cup Tournament). This resulted in a chain of transmission in Germany, including secondary cases infected during a music festival at Baden-Wuerttemberg and tertiary cases in the community, and a chain of transmission in Slovenia with secondary and tertiary cases in healthcare and community institutions.⁶⁵

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