Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.

Journal of Infection and Public Health (2008) 1, 72—77

ELSEVIER

http://www.elsevier.com/locate/jiph

REVIEW

Travel and public health

Manuel Fricker, Robert Steffen*

Division of Epidemiology and Prevention of Communicable Diseases, WHO Centre for Travellers Health, cc Institute of Social and Preventive Medicine, University of Zurich, Hirschengraben 84, CH-8001 Zurich, Switzerland

Received 25 September 2008; received in revised form 23 October 2008; accepted 24 October 2008

KEYWORDS
Travel;
Public health;
International health regulations

Summary Increasing international travel and migration can interfere with public health in both the country of destination and back home. The revised International Health Regulations (IHR) and travel disease sentinel networks are means to protect public and individual health. Public health risks related to infectious disease are higher in mass gatherings, in travellers visiting friends and relatives and in sexual encounters away from home. In contrast, in-flight transmission of infections plays only a limited role.
© 2008 King Saud Bin Abdulaziz University for Health Sciences. Published by Elsevier Ltd. All rights reserved.

Contents

1. Good news and bad news

From March through June 2002 the public health authorities in Toronto were faced with the outbreak of 225 cases of severe acute respiratory syndrome (SARS), a newly emerging respiratory infection caused by a novel coronavirus, the SARS-coronavirus [1]. All but three of the cases could be linked to one index patient, a woman who had returned from Hong Kong in February. There she had stayed on the same floor of a hotel as a physician who had travelled from Guangdong province in southern China where several hundred cases of the then unknown respiratory illness

* Corresponding author. Tel.: +41 44 634 46 08; fax: +41 44 634 49 84.
E-mail address: travclin@ifspm.uzh.ch (R. Steffen).

1876-0341/$ — see front matter © 2008 King Saud Bin Abdulaziz University for Health Sciences. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.jiph.2008.10.005

Figure 1 Spread of SARS originating from index patient in Metropole Hotel, Hong Kong, in February 2002.

had been detected in the preceding months [2] (Figure 1). The effort to contain the epidemic in Toronto included the investigation of 2132 potential cases and the identification of 23103 contacts as requiring quarantine. The provincial government of Ontario calculated the costs for coping with the epidemic at C$1.13billion [3]. The tourism industry lost C$260 million following a World Health Organisation (WHO) advisory against travel to Toronto [4].

The above episode illustrates how a highly contagious infectious disease can spread through travellers around the world within days and how this can lead to considerable human and economic losses. Fortunately, such a disease does not necessarily lead to a secondary outbreak: In June 2008, a 40 year old Dutch woman visited two bat caves in south western Uganda. After her return home 3 weeks later she developed virologically confirmed Marburg fever. Isolation measures prevented any propagation of the disease in the Netherlands [5].

According to the World Tourism Organisation (WTO), international tourism has grown at an average rate of 7% a year between 2004 and 2007, reaching 903 million international tourist arrivals in 2007 [6]. Globalisation with increasing mobility of humans poses an ever-growing challenge to international public health. Among 784 American travellers to developing countries 501 (64%) reported at least one illness during their trip. The risk of falling ill was the lowest in Southern Africa and the highest in the Indian subcontinent [7] (Figure 2). The most common illnesses acquired during travel in the developing world are diarrhoea, malaria, influenza and dengue fever [8] (Figure 3). In contrast to short-term travel, international migration can lead to changes in the epidemiology of longer lasting diseases such as tuberculosis, HIV and Hepatitis B, reflecting the *prevalence gap* of these disorders between original and receiving country [9]. Thus between 1997 and 2002, two thirds of all heterosexually acquired HIV-Infections in 12 European countries were diagnosed in people from countries with generalised HIV epidemics [10]. Of particular concern are undocumented migrants, as by definition they have little access to medical care and are afraid to report any illness by fear of being

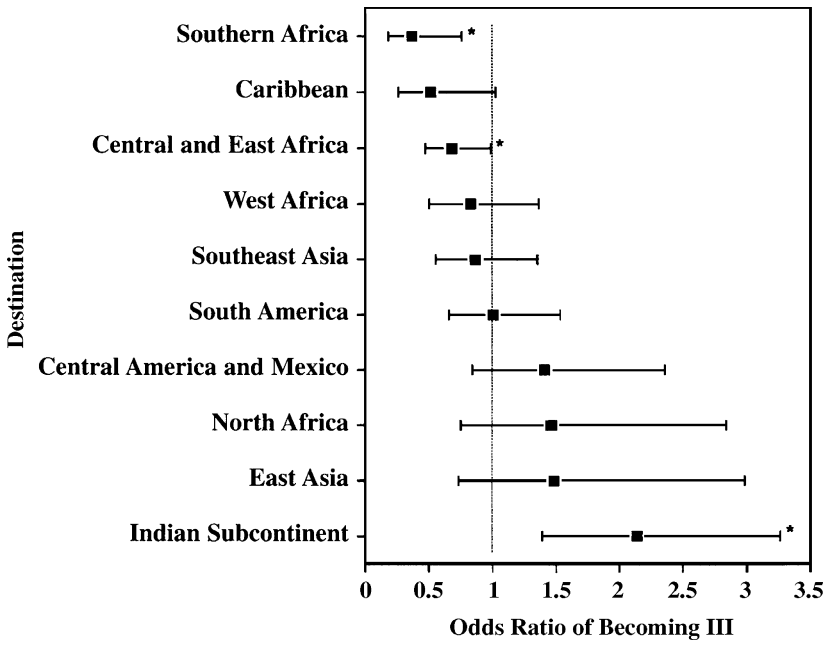

Figure 2 Odds ratio for illness by destination in American travellers using a logistic regression analysis. 95% confidence intervals are indicated. *Note*: OR-values below zero indicate reduced risk of disease within the study cohort of travellers and not a protective effect of travel to these destinations. *$p < .05$. From ref. [7], published with friendly permission of the author.

deported. They also may not only import infections occurring at home, but also others acquired during their odyssey [11].

In May 2005 the World Health Assembly adopted the revision of the International Health Regulations (IHR). The previous IHR were set up in 1969 with the purpose to monitor six different infectious diseases: cholera, plague, yellow fever, smallpox, relapsing fever and typhus. In view of newly emerging diseases such as viral hemorrhagic fevers, increasing cross-border travel and the lack of an internationally coordinated mechanism to contain international disease spread, the revision of this international agreement was initiated in the 1990s. The IHR (2005) are a set of rules that are legally binding on 194 countries around the world. They require that all countries strengthen their public health and surveillance capacities and that they notify WHO in case of a ''public health emergency of international concern'' which is determined as any event that ''constitutes a public health risk to other states through the international spread of disease and that potentially requires a coordinated international response''. In response WHO offers advice as well as technical and possibly financial support to meet these new obligations [12].

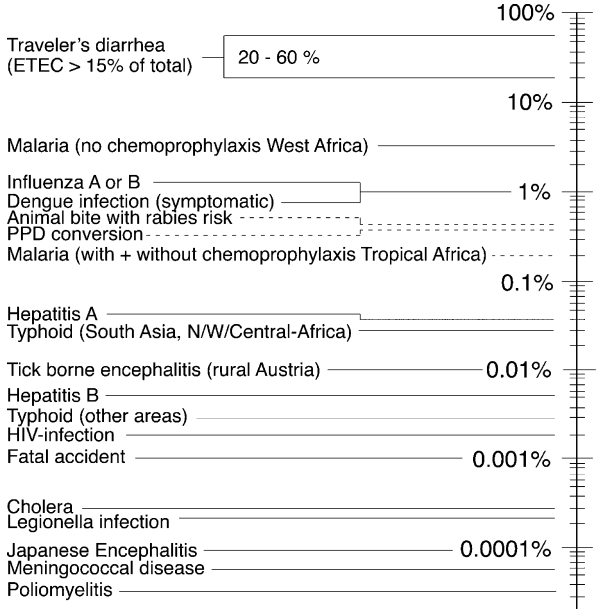

Figure 3 Incidence rate per month of health problems during a stay in developing countries-2008. From ref. [8], published with friendly permission of the author.

In addition to this intergovernmental approach of disease control and the national systems of infectious diseases surveillance, international clinician-based sentinel networks focussing on travellers such as ''GeoSentinel'' or ''TropNetEurope'' have been established. Their aim is to gather and distribute information about imported infectious diseases, thus allowing the update of travel recommendations. Sometimes, the diagnosis of a disease in a returned traveller can serve as a sentinel for

a change in the epidemiological situation in the country of travel. In November 2004 an outbreak of falciparum malaria in the eastern Dominican Republic was detected through sentinel reports in Tropnet Europe and SIMPID, the associated European and German networks for surveillance of imported infectious diseases, as well as through three reports reaching CDC from the US and Canada. The information led to investigations and control measures in the Dominican Republic. CDC recommendations for chloroquine prophylaxis in the region were adapted [13,14].

2. Mass gatherings abroad — how to cope with increased risk related to travel

The annual gathering of over 2 million pilgrims in Mecca, Saudi Arabia, is, possibly, the best occasion to study the impact of ''mass tourism'' on the health of the travellers themselves and the indigenous population. During the days 8—13 of the 12th month of the Islamic lunar calendar (355 days), people from over 140 nations undertake the Hajj, a ritual journey passing from the holy site of the Ka'aba to the plain of Arafat and back [15]. Heat, crowding and limited cooking and sanitary facilities make this event a unique breeding ground for infectious diseases. Two examples may illustrate this further:

Outbreaks of meningococcal disease among pilgrims have occurred repetitively. Disease outbreaks with *N. meningitidis* serotype A were documented in Mecca in 1987 and 1988. Consequently, Saudi health authorities implemented compulsory vaccination with bivalent meningococcal vaccine for all foreign pilgrims, annual vaccination campaigns for the local population and compulsory oral ciprofloxacin for pilgrims from sub-Saharan Africa.

After easing of these restrictions in 1999 the Hajj seasons of 2000 and 2001 have again seen outbreaks of the disease, both times with a large proportion of *N. meningitidis* serogroup W-135 [16]. In 2000, some 90 cases of meningococcal disease in returned Hajj pilgrims and their contacts were reported from nine European countries [17]. In the following year meningococcal vaccine that includes W135 became mandatory for all Hajj pilgrims.

In late 2004 two cases of polio were detected in Saudi Arabia: one in a girl from Sudan and one in a boy who had lived in Saudi Arabia for several years, indicating transmission within the country [18]. Polio had been on the way to eradication with 1200 reported paralytic cases in 2003. However, in December of that year vaccination programs in northern Nigeria were stopped amid accusations of harmful side effects of the vaccine. In the following months the disease spread along the Sahel's highways to several African countries including Sudan, which harbours Port Sudan, the main disembarking port for African pilgrims to Saudi Arabia. In May 2005 Indonesia reported the first infection with wild Poliovirus since 10 years. 298 cases followed up to December of that year. Viral gene sequencing linked the virus to Saudi Arabia. Mass immunization had to be reinstated in this Southeast Asian country where OPV3 (3× oral polio vaccination) coverage was estimated at only 70% in 2003 [19,20].

3. Air travel

In July 1979 the outbreak of influenza after a prolonged stay aboard a commercial airliner in Alaska was reported. While being unable to take off, the aircraft ventilation system was shut off. Within 72 h, 72% of the 54 passengers developed symptoms of influenza, the attack rate being higher the longer the person had stayed on board. Epidemiologically and through typing of the virus the infections could be traced back to one index patient who had developed symptoms shortly after entering the aircraft [21]. The event raised widespread concern about the danger of the spread of infectious diseases during air travel. Fortunately these fears have not been confirmed. There have been several reports on potential transmission of *Mycobacterium tuberculosis* during air travel and in some cases contact investigations found evidence of transmission of infection (i.e. positive skin tests), but none of the affected individuals has developed active tuberculosis. Based on an overall notification rate of 0.05 per 100,000 long haul passengers the aircraft cabin can be classified as a low TB incidence environment [22].

O'Connor et al. have reported on two elderly females who both developed meningococcal meningitis after having been on board of the same long haul flight during the incubation time. Genotyping revealed identical bacteria making an in-flight transmission highly probable. This remains the only report on an actual transmission of meningococcal disease during air travel [23]. The case of a patient with meningococcal disease in a chartered military aircraft on a flight across the Atlantic Ocean with 200 passengers on board led to a major international public health effort with distribution of oral ciprofloxacin to several passengers seated around

the index patient. Fortunately, no secondary infection could be confirmed [24].

Four reports have documented 7, 2, 8 and 2 cases, respectively, of in-flight or in-transit (departure gate) transmission of measles [25,26]. But despite the small number of reported in-flight transmissions of this highly contagious disease Canadian health officials did not hesitate to deny 42 non-immunised Japanese high school students their right to fly back home after the outbreak of measles in two members of the group in May 2007. Instead they were quarantined for several days [27].

Still, contrary to the belief of many travellers, aircraft cabin air quality is better than in many office buildings. About 50% of the air is recirculated after passing through high efficiency particulate air filters (HEPA). Air circulation patterns are laminar from overhead to near the floor. The sharing of air is thus reduced to very low levels beyond the same row and the two rows in front and in the back of a passenger.

The most common infectious diseases on air travel are food borne. 41 outbreaks with 11 deaths have been reported between 1947 and 1999. The most common agents were Salmonella and Staphylococcus [25].

4. Travellers visiting friends and relatives (VFRs)

Global migration has risen to 191 million in 2005 [28]. In 2002, 40% of international air travellers leaving the US were travellers visiting friends and relatives. VFRs are prone to increased health risks: They are much less likely to seek pre-travel advice and their compliance with recommendations is worse, as they often have the misconception that they are less likely to acquire diseases such as malaria ''back home''. On average, they stay abroad for a longer time and they are more likely to travel with medical conditions, being pregnant and with small children. Living in close proximity with their relatives in low socioeconomic settings they are at higher risk for diseases like tuberculosis, typhoid fever and also malaria [29]. In a study assessing fever in returned travellers from the GeoSentinel Surveillance Network VFRs were more likely to develop fever after travel to sub-Saharan Africa, south-central Asia and Latin America. They were also more likely to suffer from a vaccine-preventable illness returning from Southeast Asia (OR 5.9; 95 CI, 2.9—11.9), south-central Asia (OR, 2.7; 95% CI, 2.0—5.1) and Latin America (OR, 2.7; 95% CI, 1.1—6.6) [30].

5. Travel and sexual risk behaviour

Travellers are at increased risk to engage in sexual risk behaviour. Leaving the ''social control'' of the home country behind, making new acquaintances and maybe increased consumption of, e.g. alcohol might lower the threshold for sexual encounters with unknown partners. Reported rates of casual sexual experiences during travel vary from 5% to 51% [31]. In an Australian study only 34% of male travellers to Thailand stated not intending to have sex [32]. Men and women do not differ in their willingness to get to know new partners, but in their behaviour. Men more often pay for sex and, similarly to middle aged women, they are more likely to have sex with local partners. Younger women have sexual contacts more likely with fellow travellers and expatriates. Factors that are associated with a higher rate of casual sexual encounters in an individual include higher socioeconomic status, travelling alone or with people of the same gender, history of multiple sexual partners at home and repeated visits to a region [33].

More than 20 pathogens can be transmitted through sexual intercourse. The curable sexually transmitted infections can cause discomfort and they sometimes lead to serious complications, especially in women and small children. In addition they increase the risk for transmission of HIV up to 10 times. While incidence rates for gonococcal disease and Syphilis have remained stable in Western Europe, they have risen sharply in Eastern Europe during the 1990s [34].

6. Conclusions

Historically migration and global trade have resulted in pandemic spread of the plagues. Despite the fact that mainly tourism resulted in an exponential increase of the number of travellers, global mobility only rarely resulted in a huge public health impact. Lately, this was the case with HIV and SARS, which would have spread at a slower pace before jet age.

In this highly mobile world, modern public health measures such as surveillance, early case detection and management, vaccination, information of the public and the travellers as well as facilitated access to medical services have replaced traditional quarantine in case of epidemic. Other measures such as thermal scanning in airports have not proved effective [35]. The legal frame of the IHR and global surveillance networks (check: GOARN) are additional means to stop the spread. However, we must all realize that there is no base for complacency.

Particularly airborne infections transmitted before symptoms occur will travel before the patient realizes that he is a risk to community, and this will continue to create challenges to public health. This is illustrated annually by seasonal influenza in the northern and southern hemispheres.

Conflict of interest statement

Funding: No funding sources.
Competing interests: None declared.
Ethical approval: Not required.

References

[1] Svoboda T, Henry B, Shulman L, Kennedy E, Rea E, Ng W, et al. Public health measures to control the spread of the severe acute respiratory syndrome during the outbreak in Toronto. New Engl J Med 2004;350(23):2352—61.
[2] Centers for Disease Control and Prevention. Update: Outbreak of Severe Acute Respiratory Syndrome —Worldwide, 2003. Morbidity and Mortality Weekly Report, 2003;52(12): 241—248.
[3] Manley's comments show lack of understanding of SARS. News Release of Canada NewsWire, Toronto, 2003.
[4] KPMG. Toronto tourism revenue loss exceeds quarter of a billion. Press release of KPMG Canada, Toronto, 2003.
[5] European Center for Disease Prevention and Control. Imported Marburg Case reported in the Netherlands. Update 16 July 2008. http://www.ecdc.europa.eu.
[6] UNWTO World Tourism Barometer. vol. 6, no. 2, June 2008. p. 3, 4.
[7] Hill DR. Health problems in a large cohort of americans travelling to developing countries. J Travel Med 2000;7:259—66.
[8] Steffen R, Amitirigala I, Mutsch M. Health risks among travellers-need for regular updates. J Travel Med 2008;15(3):145—6.
[9] Gushulak BD, MacPherson DW. Population mobility and health: an overview of the relationships between movement and population health. J Travel Med 2004;11: 171—8.
[10] Hamers FF, Downs AM. The changing face of the HIV epidemic in Western Europe: what are the implications for public health policies? Lancet 2004;364:83—94.
[11] Matteeli A, Volonterio A, Gulletta M, Galimberti L, Maroccolo S, Gaiera G, et al. Malaria in illegal Chinese immigrants, Italy. Emerg Infect Dis 2001;7(6):1055—8.
[12] Web site of the WHO: http://www.who.int/csr/ihr/en/.
[13] Jelinek T, Mühlberger N. Surveillance of imported diseases as a window to travel health risks. Infect Dis Clin North Am 2005;19(1):1—13.
[14] Centers for Disease Control and Prevention. Transmission of Malaria in Resort Areas — Dominican Republic, 2004. Morbidity and Mortality Weekly Report, 2005;53(51—52): 1195—1198.
[15] Online edition of Encyclopedia Britannica: http://www.britannica.com/EBchecked/topic/295507/Islam/69.
[16] Ahmed QA, Arabi YM, Memish ZA. Health risks at the Hajj. Lancet 2006;367:1008—17.
[17] Aguilera JF, Perrocheau A, Meffre C, Hahné S, W135 Working Group. Outbreak of verogroup W135 meningococcal disease after the Hajj Pilgrimage, Europe, 2000. Emerg Infect Dis 2002;8(8):761—7.
[18] Mc Neil DG. Health Fear New Spread of Polio. The New York Times, February 10, 2005.
[19] Katz SL. Polio — new challenges in 2006. J Clin Virol 2006;36:163—5.
[20] Resurgence of Wild Polio Virus Type 1 Transmission and Consequences of Importation — 21 Countries, 2002—2005. Morbidity and Mortality Weekly Report, 2006;55(06):145—150.
[21] Moser MR, Bender TR, Margolis HS, Noble GR, Kendal AP, Ritter DG. An outbreak of influenza aboard a commercial airliner. Am J Epidemiol 1979;110:1—6.
[22] Martinez L, Blanc L, Nunn P, Raviglione M. Tuberculosis and air travel: WHO guidance in the era of drug resistant TB. Travel Med Infect Dis 2008;6(4):177—81.
[23] O'Connor BA, Chant KG, Binotto E, Maidment CA, Maywood P, McAnulty JM. Meningococcal disease — probable transmission during an international flight. Commun Dis Intell 2005;29:312—4.
[24] Riley L. Bacterial meningitis exposure during an international flight: lessons for communicable pathogens. Aviat Space Environ Med 2006;77(7):758—60.
[25] Mangili A, Gendrau MA. Transmission of infectious diseases during commercial air travel. Lancet 2005;365:989—96.
[26] Ribeiro de Barros F, Segatto TC, Luna E, Danovaro-Holliday MC, Vicari A, Toscano C. Measles transmission during commercial air travel in Brazil. J Clin Virol 2006;36:235—6.
[27] Japanese Isolated in Canada after Measles Exposure. Available at: http://www.reuters.com/article/healthNews/idUSN2932278220070529.
[28] United Nations Population Division. World Migrant Stock: The 2005 Revision Population Database, http://esa.un.org/migration/.
[29] Bacaner N, Stauffer B, Boulware DR, Walker PF, Keystone JS. Travel medicine considerations for North American immigrants visiting friends and relatives. J Am Med Assoc 2004;291:2856—64.
[30] Wilson ME, Weld LH, Boggild A, Keystone JS, Kain KC, von Sonnenburg F, Schwartz E. Fever in returned travellers: results from the GeoSentinel Surveillance Network. Clin Infect Dis 2007;44:1560—8.
[31] Matteeli A, Carosi G. Sexually transmitted diseases in travellers. Clin Infect Dis 2001;32:1063—7.
[32] Mulhall BP, Hu M, Thompson M, et al. Planned sexual behaviour of young Australian visitors to Thailand. Med J Aust 1993;158:530—5.
[33] Ward BJ, Plourde P. Travel and sexually transmitted infections. J Travel Med 2006;13(5):300—17.
[34] WHO Booklet: Global Prevalence and Incidence of Selected Curable Sexually Transmitted Infections. Overview and Estimates. Reference Number: WHO/HIV_AIDS/2001.02. Download pdf: http://www.who.int/hiv/pub/sti/pub7/en/index.html.
[35] Bell DM, World Health Organization Working Group on Prevention of International and Community Transmission of SARS. Public health interventions and SARS spread. Emerg Infect Dis 2003;10:1900—6.

Available online at www.sciencedirect.com
ScienceDirect