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Assessing the risk of importing dengue and chikungunya viruses to the European Union

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ABSTRACT

Objective: A competent vector of dengue and chikungunya viruses, *Aedes albopictus*, is present in Europe. As a first step towards assessing the likelihood of local transmission of these viruses in Europe, we estimated the number of viremic person-days among air-travellers arriving in the European Union (EU).

Methods: For dengue, we developed a Monte Carlo model with the following parameters: probability distributions based on quarterly incidences in endemic countries (years 2003–2007), passenger flow from endemic to EU countries (year 2006), duration of viremia, probability of being viremic upon arrival, distribution and period of vector activity in the EU. For chikungunya, due to scarce incidence data, we developed a model with point estimates.

Results: We estimated at 4763 (range 3067–7019) the median dengue viremic person-days in 2006 with highest estimate among travellers from Asia during the third quarter. Dengue estimates among travellers arriving in EU Aedes-infested areas from April to October were 169 viremic person-days, 130 arriving in Italy. For chikungunya, we estimated 6 viremic person-days in EU Aedes-infested areas among air-travellers from India; all occurred in Italy.

Conclusion: Our results are a first step towards a real estimation of the risk of local dengue transmission in Europe. Further research is needed to better understand vector capacity and other factors related to virus transmission in temperate climates. Information on personal protection to travellers, early diagnosis and implementation of vector monitoring and control should be a priority in EU areas where the vector is established.

Introduction

Dengue (DENV) and chikungunya viruses (CHIKV) are arthropod-borne viruses which share similar epidemiological features. Both viruses are endemic in the tropics and are transmitted to humans through the bite of infected *Aedes* mosquitoes. During recent years, the incidence of both dengue and chikungunya fever has risen worldwide (Rigau-Perez et al., 1998; Ravi, 2006). There is no vaccine available for either virus and prevention relies entirely on mosquito control and personal protection.

Dengue viruses, family *Flaviviridae*, genus *Flavivirus*, include four serotypes 1, 2, 3 and 4. The infection is characterised by a sudden onset of a self-limiting flu-like illness, fever for 2–7 days, intense headache, muscular and joint pains, retro-orbital pain, anorexia, nausea, vomiting and rashes. The incubation period is 3 to 14 days, usually lasting 4–7 days. More severe forms of the disease, such as dengue hemorrhagic fever and dengue shock syndrome can occur. Case fatality can reach 50% if severe forms are not treated (Dayal-Drager, 2004).

Chikungunya virus belongs to the family of *Togaviridae*, genus *Alphavirus*. Chikungunya fever is a self-limiting febrile disease, similar to dengue fever. Joint pains however are more marked, primarily affecting the wrist, knee, ankle and small joints of the extremities, and may last days to months. The incubation period is 2 to 12 days.

Chikungunya has been re-emerging in Sub-Saharan Africa since 2004 (Peyrefitte et al., 2007; Gravier et al., 2007; Sergon et al., 2008; Gould et al., 2008). The largest ever documented chikungunya outbreak occurred in 2005–2007 in the Indian Ocean islands (Renault et al., 2007; Sergon et al., 2007; Ramchurn et al., 2008; Sergon et al., 2008; Sissoko et al., 2008) and India (WHO, 2007; Mavalankar et al., 2007). CHIKV transmission was also recently reported in Indonesia (Laras et al., 2005), Malaysia (Soon et al., 2007) and Singapore (ProMED-mail, 2008). Although not considered a life-threatening disease, severe forms of chikungunya infection were described and co-morbidity with chikungunya infection was mentioned in death certificates during the 2005–06 epidemic in Reunion island (Renault et al., 2007).

Aedes aegypti is the most competent vector for both dengue and chikungunya viruses (Dayal-Drager, 2004; Shope and Mackenzie, 2004). Present in Southern Europe in the first half of the 20th century this species was indicated as the main vector during the 1927–28 dengue epidemic in Athens (Rosen, 1986). Eliminated then from continental

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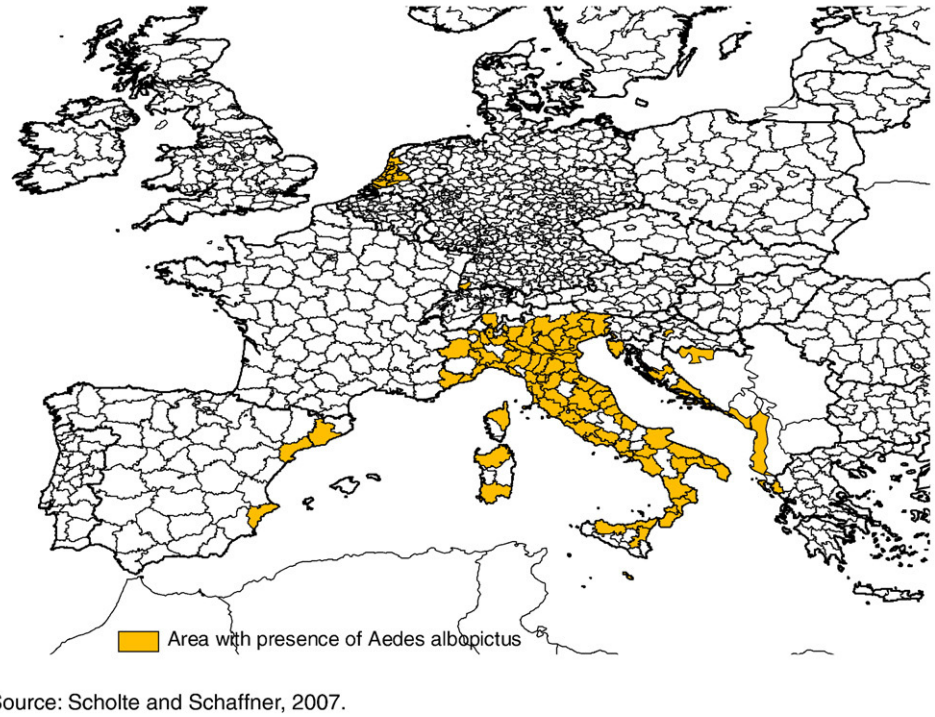

Fig. 1. Geographical distribution of *Aedes albopictus* in Europe, by province, 2007. Source: Scholte and Schaffner (2007).

Europe, re-establishment has not been reported since. *A. aegypti* has been confirmed since 2004–2005 in the Autonomous Region of Madeira, a Portuguese Island in the Atlantic Ocean (Almeida et al., 2007).

By the end of 2007, *Aedes albopictus* has been observed in certain areas of the following European Union (EU) Member States: Italy, Slovenia, Spain, France, Greece, The Netherlands and Germany (Fig. 1). *A. albopictus* was pointed out as the main vector during the chikungunya epidemic in the Reunion island, where a single virus mutation was associated with a significant increase of CHIKV infectivity for *A. albopictus* (Tsetsarkin et al., 2007), and during the only up-to-date chikungunya epidemic in Europe (Rezza et al., 2007).

Air-passenger flow to the EU Member States rose from 20.2 million in 2003 to 27.5 million in 2006 from dengue endemic countries, and from 5.9 million in 2003 to 7.7 million in 2006 from countries reporting recent chikungunya infections.

Considering the presence of *A. albopictus* and the potential of introduction of *A. aegypti* in continental Europe, together with the increasing number of overseas travellers, EU Member States should consider the risk of introduction and transmission of both DENV and CHIKV in Europe a potential public health issue (ECDC, 2006).

This study aimed to estimating the number of days during which travellers from endemic countries are viremic with DENV and CHIKV upon arrival in the EU in 2006, both in terms of space (*Aedes*-infested countries and provinces) and time (seasons during which the vector is active), as a first step towards estimating the likelihood of local transmission of DENV and CHIKV within continental Europe.

Methods

The model

To estimate the number of DENV and CHIKV viremic person-days among air-travellers arriving during each quarter of 2006 in EU Member States, we developed a model (Eq. (1) below). The year 2006 was chose because it was the most recent year with more complete available disease incidence and air-traveller data.

The estimated number of viremic person-days (V) among air-travellers arriving from an endemic/epidemic country (c) to an EU Member State (j) during each quarter (q) was a function of:

(i) the cumulative disease incidence rate [I] in each endemic/epidemic country [c] for each quarter [q];
(ii) the estimated proportion of asymptomatic infections [a];
(iii) the likelihood for an infected individual of being viremic at the moment of travelling [t];
(iv) the quarterly number of air-passengers [P] from each endemic/epidemic country [c] to each EU Member State [j];
(v) the duration of viremia [D].

We assumed that mildly symptomatic and asymptomatic infections were not detected by local surveillance systems. We assumed that symptomatic, mildly symptomatic and asymptomatic infections were equally potential source of transmission to mosquitoes. We applied infection incidence (disease incidence adjusted for asymptomatic and mildly symptomatic infections) to passenger flows, as if passengers were a random sample of the local population.

The likelihood of an infected person being viremic when flying or soon after was estimated as a time fraction of the quarter during which an infected person would be viremic. Since we used quarterly incidences and a fixed duration of 7 days viremia for both dengue and chikungunya (see below), the likelihood of being viremic used in the model was 7 days out of the 91.25 days in a quarter. The parameter [t] was therefore 0.0767 for both DENV and CHIKV. For this we assumed that the likelihood of being viremic was constant throughout the quarter. We also assumed that viremic travellers took the plane on average half way through their viremic period and spent therefore half of their viremia in Europe.

$$V^{q}_{c\to j} = \frac{I^{q}_{c}}{1-a} \times t \times P^{q}_{c\to j} \times \frac{D}{2} \qquad (1)$$

In the absence of detailed information on intra-national mobility, we assumed that air-travellers arriving in an EU Member State were distributed across the territory according to the underlying population

Table. 1
Estimation of population living in *Aedes albopictus*-infested area by EU Member State as to December 2007.

EU member state	Proportion of population living in *Aedes*-infested areas (%)	Description of the area
Italy	80	Almost all Italian territory
Slovenia	18	Primoska and Ljubliana
Spain	8	Barcelona and Alicante and Tarragona municipalities
France	2	Districts of Alpes-Maritimes, Var and Haute-Corse
Greece	1.5	Corfu island
The Netherlands	0	Only inside green houses
Germany	0	Eggs collected in ovitraps in Baden-Württemberg, no adult activity documented

geographical distribution. To estimate the number of viremic person-days spent in EU *Aedes*-infested areas [$V^q_{c\to j}$], we therefore adjusted the quarterly estimates [$V^q_{c\to j}$] for the proportion of each EU Member State population living in *Aedes*-infested areas [m_j] (Eq. (2) below).

$$V^q_{c\to mj} = V^q_{c\to j} \times m_j \quad (2)$$

We included in the model only endemic/epidemic countries for which combined data on disease incidence and air-passenger flow were available. We include in the model all 27 EU Member States, including Romania and Bulgaria although in 2006 these two countries were not EU Member States yet. Definition, values and sources of each parameter used in the model are provided in Appendix A.

Geographical distribution and activity period of A. albopictus in Europe

We reviewed entomological publications and reports to identify European areas (3rd administrative level) where potential vectors were established. In particular, we used the latest available map indicating EU areas where *A. albopictus* was established up to 2007 (Scholte and Schaffner, 2007). We estimated the proportion of the national population living in *Aedes*-infested areas using demographic data for EU member states provided by Eurostat.[1] Estimation proportions presented in Table 1 were used to compute viremic person-days spent in *Aedes*-infested areas for each EU Member State.

Quarters during which *A. albopictus* is active were considered quarter 2 (April to June) and quarter 3 (July to September) (Di Luca et al., 2001; Toma et al., 2003).

Disease incidence

We first reviewed publications made available on PubMed, the World Health Organization, the USA Centres for Disease Control and Prevention and surveillance reports at the Tropical and International Department at the French Heath Surveillance Institute, in order to identify countries where autochthonous dengue and chikungunya cases had been reported at least once from 2003 to 2007 inclusive.

We then searched for quarterly incidence data for these countries through WHO regional offices, WHO Dengue Network and national Ministries of Health. When for one country only annual incidences were available, we distributed annual cases to each quarter proportionally to the quarterly case distribution of a neighbouring country for which documented quarterly incidences were available. For this purpose, we classified countries into the following regions: Asia: South-East Asia mainland, South-East Asian islands, South Asia, China and Taiwan; Africa: East African islands; America: South America highlands and lowlands, Central America and The Caribbean. We did not find incidence data for countries in the Middle East, Sub-Saharan Africa and Oceania. Pacific islands had intense well documented but sporadic epidemics and were too far apart to estimate quarterly incidences.

Box 1
Parameters used to build the gamma distribution.

For each real distribution:
- Shape = mean^2 / variance
- Scale = variance / mean

Minimum and maximum values of each real distribution were also used as limits of the gamma distribution.

Quarterly cumulative incidence rates were computed in countries endemic for dengue and chikungunya using the 2005 demographic estimates prepared by the United Nations Department of Economics and Social Affairs, available online (Department of Economic and Social Affairs — Population Division, 2005).

For dengue we developed quarterly incidence distributions for 2006 based on the 2003–2007 incidences, in order to take into account some degree of reporting uncertainty. Quarterly incidence of countries with similar ranges and seasonal patterns were aggregated into geographical groups. We therefore built one incidence distribution for each quarter for 16 geographical groups (Appendix B). Countries with occasional missing data were included. Countries with limited or no data available for the whole period were excluded. A gamma distribution function (see parameter details in Box 1) was applied using R freeware[2] to obtain theoretical probability distributions which best fitted the real incidence distributions of each quarter and group of countries. We then ran one thousand Monte Carlo simulations with the parameters listed above to obtain quarterly viremic person-days distribution estimates for each endemic/epidemic country and each EU country of destination.

We were unable to compute incidence distributions for chikungunya due to scarce data. We therefore used point incidence, instead of incidence distribution.

Asymptomatic infections and viremic period

Proportions of asymptomatic or mildly symptomatic dengue infections may range from 75.7% to 90.2% (Burke et al., 1988; Endy et al., 2002; Porter et al., 2005). We used in our model a fixed value of 80% asymptomatic or mildly symptomatic dengue infections.

Studies carried out in Indonesia (Laras et al., 2005), Comoros (Sergon et al., 2007) and Reunion Island (Perrau et al., 2007) estimated the proportion of asymptomatic chikungunya infections between 10% and 15.7%. For chikungunya, we used a fixed 15% as the proportion of asymptomatic or mildly symptomatic infections.

An infected person remains infectious as long as the virus circulates in his/her blood at titres high enough to infect a female mosquito taking a blood meal. The duration of dengue viremia in humans has been documented including 1–2 days before the onset of symptoms and 4–6 days for most of cases after the first symptoms (Gubler et al., 1981; Vaughn et al., 1997; Dayal-Drager, 2004). The duration of chikungunya viremia is not well documented and we assumed to be similar to the duration of dengue viremia. Considering a worse scenario for this parameter, we used in our model a fixed duration of viremia of seven days for both infections.

Air-passengers flow

Data on air-passenger flow were obtained from Eurostat (free of charge online database of the Statistical Office of the European

[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/population/data/database.

[2] http://www.r-project.org/.

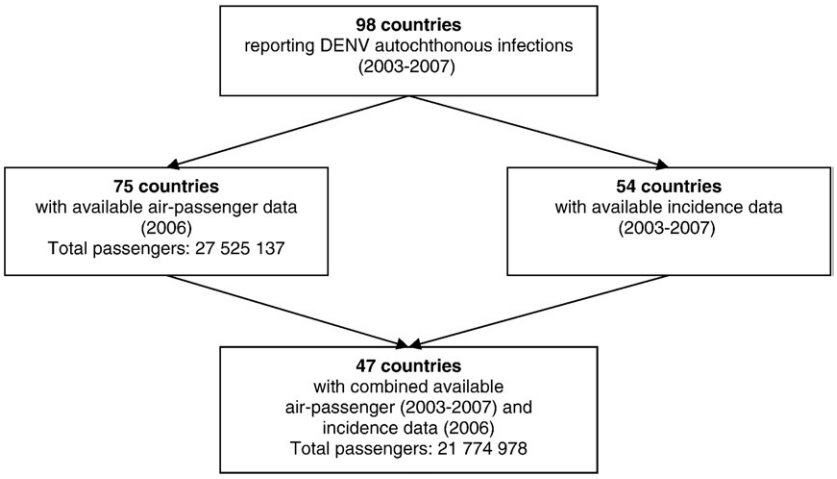

Fig. 2. Number of non-EU countries and overseas EU territories with reported DENV autochthonous infections, available dengue incidence for 2003–2007 and available passenger data flow for 2006.

Communities) and the On Flight Origin and Destination (OFOD) database maintained by the International Civil Aviation Organisation. Both databases record direct flight passengers.[3] For each air route, the highest number of passengers reported by either of the two databases was kept in the model. We accessed the Passenger Intelligence Services database (PaxIS) from the International Air Transport Association for 2 pairs of countries (passengers arriving in Italy from India and Reunion Island). This database also takes into account indirect flights[4] and served as a model input to estimate chikungunya viremic person-days arriving in Italy. Access to the PaxIS database for all countries was not possible due to budget constraints.

Results

Dengue viremic person-days estimates

A total of 98 non-EU countries and overseas territories of EU Member States were identified reporting dengue autochthonous cases at least once between 2003 and 2007. Combined quarterly dengue incidence and air-traveller data were available for 47 countries (48%) on which the estimates below were based (Fig. 2).

For 2006, a median of 4763 dengue viremic person-days (range: 3067–7019; 25–75% inter-quartiles: 4368–5195) was estimated to be spent in the 27 EU member states by air-travellers arriving from endemic countries. Estimates were higher in the third quarter (median: 1376 viremic person-days) and subsequently in the first, second and fourth quarters (medians: 1312, 985 and 954 viremic person-days respectively). The highest estimates were among travellers from Asian countries during the third quarter (median: 740 person-days), followed by travellers from South America during the first quarter (median: 579 person-days), and again Asian countries during the second and the first quarters (medians 519 and 475 person-days respectively). The lowest estimates were among travellers from the Caribbean and Central America during any of the four quarters of the year (medians 30 to 168 viremic person-days) (Fig. 3; for single country's estimates, see Appendices C and D).

During the two combined quarters during which *A. albopictus* is active in Europe (April to September included), a median of 169 dengue viremic person-days was estimated being spent in *Aedes*-infested areas (range: 85 and 307; 25%–75% inter-quartiles: 145–199 person-days). The median estimate was lower in the second (75 person-days) than in the third quarter (92 person-days). During the second quarter, medians were 60, 12, 3 and less than one dengue viremic person-days in Italy, Spain, France and Greece, respectively. During the third quarter, medians for the same countries were 70, 17, 4 and less than one dengue viremic person-days (Fig. 4). Slovenia is not presented as no data for air-passengers were available.

Chikungunya viremic person-days estimates

A total of 17 non-EU countries and overseas territories of EU Member States reported CHIKV transmission during at least once from 2003 to 2007. Quarterly chikungunya incidences were found for 3 countries: India, Mayotte and Reunion Island. Combined air-travellers and quarterly chikungunya incidences were available only for India using the Eurostat or OFOD databases. The model therefore computed estimates for the whole EU only with air-travellers from India. Separate estimates for Italy were obtained for air-travellers from India and Reunion Island using the PaxIS database (Fig. 5).

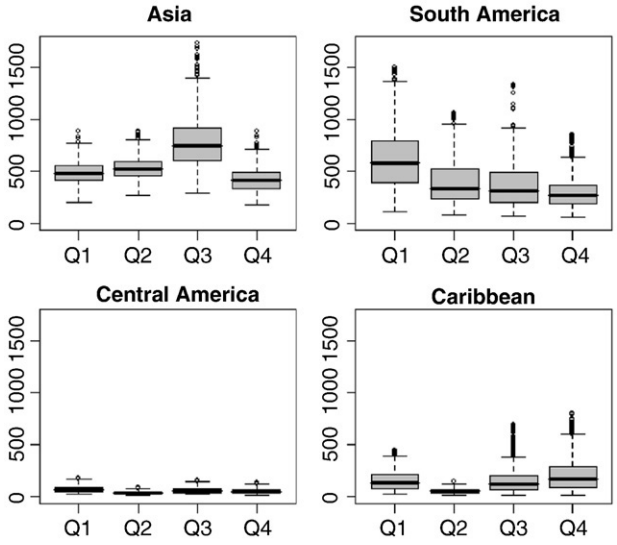

Fig. 3. Distributions of quarterly estimated dengue viremic person-days by major endemic areas for travellers arriving in all 27 European Member States, 2006. Note: The thick horizontal bar inside the gray boxes corresponds to the median of the distribution. The lower and upper limits of the gray boxes correspond to the 25 (Q_1) and the 75 (Q_3) percentiles of the distribution. The lower and upper whiskers correspond to: $x_{\text{lower whisker}} = \min\{x_i | x_i \geq Q_1 - 1.5\times(Q_3 - Q_1)\}$, $x_{\text{upper whisker}} = \max\{x_i | x_i \leq Q_3 + 1.5\times(Q_3 - Q_1)\}$. The small circles correspond to any data points which lie beyond the extremes of the whiskers.

[3] A passenger flying from India to Italy with a connecting flight in Kuwait was reported in Eurostat and OFOD databases as a passenger arriving in Italy from Kuwait.

[4] A passenger flying from India to Italy with a connecting flight in Kuwait appeared in PaxIS database as a passenger arriving in Italy from India.

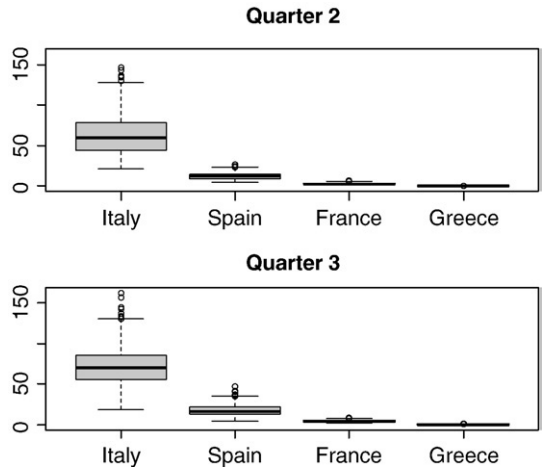

Fig. 4. Distributions of dengue viremic person-days arriving in EU *Aedes albopictus*-infested areas by country of destination, second and third quarters, 2006. Note: see note of Fig. 3 for box-plot element description.

Throughout 2006, we estimated a total of 175 chikungunya viremic person-days among air-travellers arriving to all 27 EU member states from India. Estimates were highest during the third and the second quarters (100 and 67 person-days respectively). We estimated 6 viremic person-days spent by travellers arriving in *Aedes*-infested areas, all in Italy.

Using 2006 PaxIS passenger data for the pairs India–Italy and Reunion Island–Italy, we estimated respectively 8 and 2 viremic person-days among travellers arriving in the Italian *Aedes*-infested provinces during the second and the third quarters.

Discussion

We have attempted to quantify the risk of importation of DENV and CHIKV to EU Member States by estimating the number of viremic person-days spent by travellers in 2006 upon arrival in EU in general, and in EU *Aedes*-infested areas in particular. The number of viremic person-days during the two quarters when the vector is active in Europe should be interpreted as the number of days during which a viremic person can infect an *Aedes* mosquito in Europe.

Estimates were based on a model including the latest data on the worldwide reported incidence of the diseases, air-passenger flow from endemic/epidemic countries to the EU, and proportion of the EU population living in *Aedes*-infested areas. We took into account the proportion of asymptomatic infections, the likelihood of being viremic upon arrival to an EU Member State and the duration of viremia. Other studies have used mathematical modelling to estimate the risk of dengue and chikungunya infection in travellers to Singapore (Massad et al., 2008; Massad and Wilder-Smith, 2009). Their model includes parameters taking into account the duration of stay of the traveller, as well as entomological factors such as vector mortality. Whereas such models can be very useful for risk assessment, their current application at the EU level is limited due to scarce entomological data. Our work takes into account passenger flows from all endemic countries, an aspect not addressed by previous studies.

We estimated that in 2006 the number of viremic person-days was sizeable for both DENV and CHIKV. Considering the EU *Aedes*-infested areas and the mosquito active period, we estimated a median number of 169 and a point value of 6 viremic person-days for dengue and chikungunya respectively.

Dengue estimates were highest among travellers arriving from Asia and notably South-East Asia. Our geographical travel origin and seasonal patterns of viremic travellers were similar to the patterns of ill returned travellers with dengue reported by the GeoSentinel Surveillance Network (Schwartz et al., 2008). Regarding the EU *Aedes*-infested areas, Italy was clearly the most exposed EU Member State. Mainly due to the presence of the vector in almost all its provinces, Italy accounted for more than three quarters of all dengue viremic person-days at any time during the period when local transmission has the potential to be initiated.

Estimates of chikungunya viremic person-days were much lower than those of dengue. If compared with DENV, fewer countries reported CHIKV transmission. In general these countries are less popular destinations for tourists. Chikungunya fever was a new or re-emerging disease for many countries in which no specific surveillance system was in place before the 2005–2006 outbreaks in the Indian Ocean. This led to scarce chikungunya incidence data. However, our model showed that Italy remains the most exposed EU Member State when looking at CHIKV viremic person-days arriving in *Aedes*-infested areas.

Our estimates suggest that during the peak of the Indian outbreak (quarters 2 and 3 of 2006) 8 chikungunya viremic person-days were spent in the Italian *Aedes*-infested areas. Given that reported chikungunya incidence in India was much lower in 2007 (source: Directorate of National Vector Borne Disease Control Programme, India), the corresponding number of viremic person-days spent in Italy by air-travellers from India was probably lower as well in quarters 2 and 3 2007, while local transmission was initiated with an index case

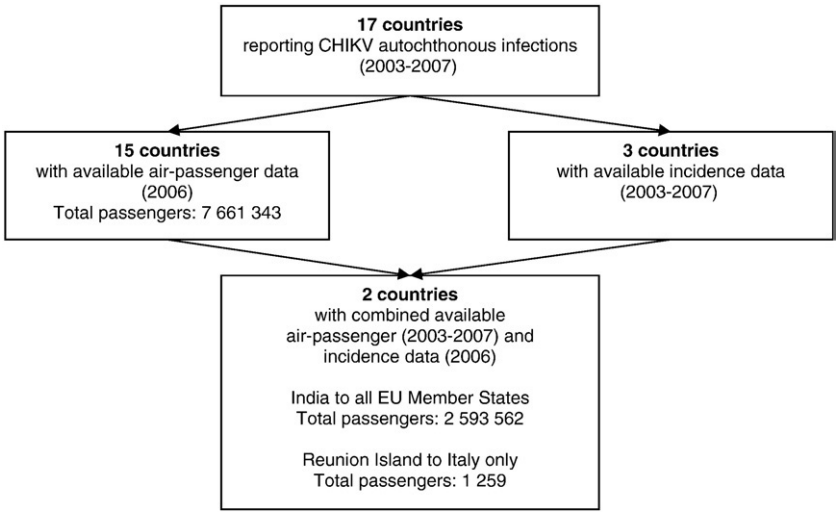

Fig. 5. Number of non-EU countries and overseas EU territories with reported CHIKV autochthonous infections, available chikungunya incidence for 2003–2007 and available passenger data flow for 2006.

returning from India (Rezza et al., 2007). This could suggest that few CHIK viremic person-days suffice to trigger local transmission, confirming the high vector competence of *A. albopictus* for CHIKV.

As it happened for chikungunya, the possibility that local virus transmission could occur in Europe also for dengue cannot be ruled out. Dengue epidemics with *A. albopictus* as the main vector have been already described (Effler et al., 2005; Gratz, 2004; Michault, 1998), but little is known about competence and capacity of *A. albopictus* for dengue in temperate climates (for instance, by how many days would lower temperatures increase the extrinsic incubation period). The possibility for better adaptation to the vector should be also considered, as it was the case for CHIKV during the Reunion Island epidemic (Tsetsarkin et al., 2007).

We are aware of the limitations to the precision of our estimates. A first limitation was related to the availability and completeness of incidence data. For some countries which were known to have experienced DENV or CHIKV transmission, no quarterly incidence data were available. Most notably, we could not find data for Sub-Saharan Africa. In addition, when data were available, case definitions or reporting criteria varied across countries. In any case, data reported through surveillance systems were far from exhaustive, and usually underestimated.

A second limitation was related to passenger data. Some routes were not covered by the Eurostat or OFOD databases, for instance for Reunion Island and Mayotte, two French overseas territories that experienced chikungunya outbreaks in 2005–06, and for the French Guyana, where dengue is known to be endemic. Both Euorstat and OFOD report only direct flights and the link is lost with the endemic country when passengers make a flight connection. This was only partially offset by the use of PaxIS database for India–Italy and Reunion Island–Italy routes, as far as chikungunya was concerned.

The above limitations may have led to lowering the estimates at different degrees. However, other limitations listed below may have led to inflating the estimates.

Disease incidence in air-travellers is probably lower than in general population, and not equal, as we assumed in our model. It is reasonable to consider that many travellers were either tourists or business travellers, often staying in mosquito-free air-conditioned hotels and using personal protection. However, these types of travellers would have higher risk of becoming sick and viremic than the local population due to a lack of immunity from previous infections.

Another major limitation inflating our estimates was the decision of fixing high values for the proportion of asymptomatic infection (80% for dengue) and for the duration of viremia (7 days for both infections). In this case we opted for a worse scenario, but in reality, one may argue that these variables would not be always so high.

Finally the decision of taking on average half of viremia duration being spent upon arrival in the EU did not take into account that, for symptomatic infections, most of the days of viremia overlap with symptoms. In such a situation, the person might decide to delay the flight and spend in fact the whole viremic period outside of the EU.

Our estimates provide useful information to focus surveillance and control measures depending of the period of the year, the endemic country of travel origin and the Member State of travel destination. More complete and accurate data are needed, both with regards to disease surveillance and passenger flow.

Until more detailed risk assessments are undertaken, it is important for travellers to avoid CHIKV or DENV infections through personal protection when visiting endemic countries. Upon the travellers' return, the capacity for timely diagnosis and implementation of vector control measures should be considered a priority in EU areas harbouring the vector, particularly in Italy, where the vector is widespread during the summer.

Monitoring the introduction of the vector in new areas and enabling rapid containment of its establishment and spread are equally important measures to limit the risk of experiencing (or re-experiencing, for chikungunya) local transmission in continental Europe.

Conflict of interest
This study was funded by ECDC. Authors declare no conflicting interest.

Related paper

An official ECDC report is in preparation.

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Appendix A. Symbol, description, value, and source of the parameters used.

	Symbol	Description of parameter	Values		Source
			DEN	CHIK	
Inputs	I_c^q	Incidence of the disease in country c during quarter q as reported by the local surveillance system	Distributions by geographical region (see Appendix B)	Point incidence	WHO, MoH
	a	Proportion of asymptomatic infections	0.8	0.15	Porter et al. (2005) Perrau et al. (2007)
	t	Likelihood for an infected individual of being viremic at the moment of travelling (7 days of viraemia over a mean of 91.25 days in one quarter)	0.0767	0.0767	Dayal-Drager (2004)
	D	Duration of viraemia expressed in days	7	7	Dayal-Drager (2004)
	$P_c{}^q{}_{\to j}$	Number of passengers travelling from country c to country j by plane during quarter q	See Fig. 2 (or Table A1)	See Fig. 5 (or Table A2)	Eurostat, ICAO, IATA
	m_j	Proportion of population living in areas where the vector is established within country j	See Table 1	See Table 1	Based on Scholte and Schaffner (2007)
Outputs	$V_c{}^q{}_{\to j}$	Number of imported viraemic person-days travelling from country of departure c to country of destination j during quarter q	Distributions	Point estimates	Model
	$V_c{}^q{}_{\to mj}$	Number of imported viraemic person-days arriving from country of departure c to areas where the vector is established in country j during quarter q	Distributions	Point estimates	Model

Table A1
Countries and overseas EU territories with reported DENV autochthonous infections, available dengue incidence for 2003–2007 and available passenger data flow for 2006.

Geographic area	Countries reporting DENV autochthonous infections (2003–2007) [Nb of countries]	Countries reporting DENV autochthonous infections (2003–2007) and available air-passenger data (2006) [Nb of countries] (air-passengers to EU in 2006)	Countries with available quarterly dengue incidence data (2003–2007) [Nb of countries]	Countries with available quarterly dengue incidence data (2003–2007) and air-passenger data (2006) [Nb of countries] (air-passengers to EU in 2006)
All countries	[98]	[75] (27525137)	[54]	[47] (21774978)
North America ($)	Mexico [1]	Mexico [1] (1480553)	Mexico [1]	Mexico [1] (1480553)
Central America	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama [7]	Costa Rica, Guatemala, Honduras, Nicaragua, Panama [5] (234331)	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama [7]	Costa Rica, Guatemala, Honduras, Nicaragua, Panama [5] (234331)
The Caribbean	Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Montserrat, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Turks and Caicos Islands, Trinidad and Tobago [22]	Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Turks and Caicos Islands, Trinidad and Tobago [19] (3592968)	Anguilla, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Jamaica, Montserrat, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Turks and Caicos Islands, Trinidad and Tobago [18]	Anguilla, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Islands, Cuba, Dominica, Dominican Republic, Grenada, Jamaica, Puerto Rico, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Turks and Caicos Islands, Trinidad and Tobago [17] (3448884)
South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, French Guyana, Paraguay, Peru, Suriname, Venezuela [12]	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Venezuela [11] (4870162)	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, French Guyana, Paraguay, Peru, Suriname, Venezuela [12]	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Venezuela [11] (4870162)
Sub-Saharan Africa	Angola, Burkina Faso, Cameroon, Djibouti, Gabon, Guinea, Ivory Coast, Kenya, Lesotho, Mozambique, Nigeria, Senegal, Somalia, Sudan [14]	Angola, Burkina Faso, Cameroon, Djibouti, Gabon, Guinea, Ivory Coast, Kenya, Mozambique, Nigeria, Senegal, Sudan [12] (2322874)	[0]	[0] (NA)
Indian ocean islands	Comoros, Madagascar, Mayotte, Mauritius, Reunion Island, Seychelles [6]	Comoros, Madagascar, Mauritius, Seychelles [4] (970167)	[0]	[0] (NA)
Middle East	Saudi Arabia, Yemen [2]	Saudi Arabia, Yemen [2] (336430)	[0]	[0] (NA)
South-Central Asia	Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka [8]	Afghanistan, Bangladesh, India, Maldives, Nepal, Pakistan, Sri Lanka [7] (3650407)	Bangladesh, India, Maldives, Nepal, Sri Lanka [5]	Bangladesh, India, Maldives, Nepal, Sri Lanka [5] (3231946)
China, Taiwan	China, Taiwan [2]	China, Taiwan [2] (4526816)	China [1]	China [1] (4009095)
South-East Asia	Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Vietnam [11]	Brunei Darussalam, Indonesia, Malaysia Myanmar, Philippines, Singapore, Thailand, Vietnam [8] (4566820)	Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Vietnam [10]	Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam [7] (4500007)
Oceania and Pacific islands	Australia, Cook Islands, Easter Islands, Fiji, Hawaii, Micronesia, Marshall Islands, New Guinea, New Caledonia, French Polynesia, Palau, Papua, Samoa [13]	Australia, Fiji, French Polynesia, New Caledonia [4] (973609)	[0]	[0] (NA)

($) sporadic local transmission was also reported in Texas (USA).

Table A2
Countries and overseas EU territories with reported CHIKV autochthonous infections, available chikungunya incidence for 2003–2007 and available passenger data flow for 2006.

Geographic area	Countries reporting CHIKV autochthonous infections (2003–2007) [Nb of countries]	Countries reporting CHIKV autochthonous infections (2003–2007) and available air-passenger data (2006) [Nb of countries] (air-passengers to EU in 2006)	Countries with available quarterly chikungunya incidence data (2003–2007) [Nb of countries]	Countries with available quarterly chikungunya incidence data (2003–2007) and air-passenger data (2006) [Nb of countries] (air-passengers to EU in 2006)
All countries	17	15	3	2
South-East Asia Islands	Indonesia, Malaysia, Singapore [3]	Indonesia, Malaysia, Singapore [3] (2268737)	[0]	[0]
South-Central Asia	India, Maldives, Sri Lanka [3]	India, Maldives, Sri Lanka [3] (3122247)	India [1]	India [1] (2593562)
Sub-Saharan Africa	Gabon, Cameroon, Kenya, Senegal, Sudan [5]	Gabon, Cameroon, Kenya, Senegal, Sudan [5] (1361047)	[0]	[0]
East Africa Islands	Comoros, Madagascar, Mayotte, Mauritius, La Réunion, Seychelles [6]	Comoros, Madagascar, Mauritius, Seychelles [4] (970167)	Mayotte, La Réunion [2]	La Réunion [1] (only passenger flow to Italy: 1259) ($)

($) PaxIS database.

Appendix B. Quarterly distributions of incidence of cases per 100 000 for the years 2003–2007 by group of countries with similar quarterly dengue incidence rates and seasonal incidence pattern.

Continent or subcontinent		Group countries[a]	Quarter 1 (January–March)				Quarter 2 (April–June)				Quarter 3 (July–September)				Quarter 4 (October–December)			
			Mean	Variance	Min	Max	Mean	Variance	Min	Max	Mean	Variance	Min	Max	Mean	Variance	Min	Max
Asia	1	Bangladesh, India, Myanmar, Sri Lanka	2.56	25.04	0.00	17.80	3.33	15.70	0.00	12.89	6.46	47.38	0.07	19.37	4.83	48.53	0.03	24.22
	2	Maldives	85.90	8508.49	3.04	228.27	90.27	10064.16	0.00	255.62	94.59	5606.17	0.61	176.90	115.81	6016.25	7.90	193.01
	3	Cambodia, Lao People's Democratic Republic, Philippines, Thailand, Viet Nam	7.98	17.10	1.45	18.66	23.16	159.07	4.34	57.60	37.49	1538.71	12.53	203.24	14.58	61.91	4.01	34.49
	4	Malaysia, Singapore	44.22	440.70	17.22	70.36	36.95	104.91	18.96	54.35	39.36	1744.73	13.46	144.24	27.48	644.83	10.42	84.19
	5	Indonesia, Timor-Leste	24.87	535.40	0.00	81.94	8.84	108.66	0.00	30.83	3.09	14.08	0.00	9.23	5.79	20.21	0.00	15.12
	6	China, Nepal	5.90E−05	1.50E−08	0.00	3.80E−04	1.40E−03	1.30E−05	0.00	0.01	8.00E−03	3.20E−04	0.00	0.05	0.01	9.20E−04	0.00	0.09
North America	7	Mexico	6.25	26.76	1.48	14.30	2.94	5.94	0.70	6.73	5.60	21.49	1.33	12.81	4.99	17.05	1.18	11.41
Central America	8	Belize, Nicaragua, Guatemala, Panama	19.37	963.00	0.00	140.74	5.45	36.62	0.00	19.80	10.57	132.35	0.00	37.65	10.51	132.33	0.00	33.54
	9	Costa Rica, El Salvador, Honduras	101.40	4182.15	34.14	275.99	47.75	927.58	16.07	129.97	90.85	3357.37	30.59	247.28	80.93	2664.29	27.25	220.29
America Caribbean[b]	10	Cuba, Jamaica, Saint Lucia, Saint Vincent and the Grenadines, Bahamas (Q 1–4), Anguilla (Q 1 and 4), Aruba (Q 1 and 3), British Virgin Islands, Cayman Islands (Q 1), Grenada (Q 3 and 4), Saint Kitts and Nevis (Q 1, 3 and 4), Montserrat (Q 3), Turks and Caicos Islands (Q 4)	4.00	104.38	0.00	62.84	1.48	10.24	0.00	11.76	2.01	28.61	0.00	31.69	2.59	30.64	0.00	24.77
	11	Barbados, Dominican Republic, Puerto Rico, Trinidad and Tobago (Q 1–4), Grenada (Q 2), Dominica (Q 3)	19.38	373.14	0.00	60.74	9.08	53.36	0.00	25.71	24.85	962.07	0.00	140.51	37.16	2268.43	0.00	192.22
South America	12	Guyana	4.05	1.96	2.66	5.86	9.24	46.27	2.00	16.78	2.77	1.96	0.53	4.13	0.08	0.03	0.00	0.40
	13	Brazil, Colombia, Suriname, Venezuela	51.21	1900.69	2.23	158.35	37.19	1190.52	2.00	137.64	28.99	2174.16	3.12	220.49	30.13	686.63	1.78	119.15
	14	Bolivia, Ecuador, Peru	26.74	386.50	7.65	65.69	13.44	59.53	4.03	26.49	1.95	3.65	0.20	7.11	7.28	93.42	0.34	33.57
	15	Paraguay	49.36	8202.88	1.02	209.69	38.29	4954.77	0.75	162.89	6.05	122.17	0.13	25.63	13.99	659.08	0.29	59.43
	16	Argentina, Chile	0.48	1.61	0.00	4.08	0.29	0.54	0.00	2.37	0.09	0.06	0.00	0.81	0.13	0.12	0.00	1.11

Note:

[a] Countries for which dengue virus circulation was reported, but no data of dengue fever incidence on human population were available: - Asia: Afghanistan, Bhutan, Brunei Darussalam, Pakistan, Saudi Arabia, Taiwan, Yemen - Oceania: Australia - Pacific: Cook Islands, Easter Islands, Fiji, Hawaii, Micronesia, Marshall Islands, New Guinea, New Caledonia, French Polynesia, Palau, Papua, Samoa - Africa: Angola, Burkina Faso, Cameroon, Comoros, Djibouti, Gabon, Guinea, Ivory Coast, Kenya, Lesotho, Madagascar, Mauritius, Mayotte, Mozambique, Nigeria, Réunion Island, Senegal, Seychelles, Somalia, Sudan.

[b] Carribean islands were very variated in terms of incidence. One country may be in both groups 10 and 11 according to the quarter. In parenthesis the quarter for which the country contributed to the distribution. Countries and quarters with zero incidence reported: Antigua and Barbuda (Q 1–4), Aruba (Q 2, 4), British Virgin Islands, Cayman Islands (Q 2, 3 and 4), Dominica, Montserrat (Q 1, 2 and 4), Grenada (Q 1), Saint Kitts and Nevis (Q 2), Turks and Caicos Islands (Q 1, 2 and 3).

Appendix C. Estimated distribution of dengue viremic person-days among travellers by country of departure from the American continent.

Country	Quarter 1 (January–March)					Quarter 2 (April–June)					Quarter 3 (July–September)					Quarter 4 (October–December)				
	Min	25%	Median	75%	Max	Min	25%	Median	75%	Max	Min	25%	Median	75%	Max	Min	25%	Median	75%	Max
Brazil	22	173	339	559	1227	15	86	186	378	963	21	56	135	301	1299	12	93	155	260	771
Dominican Rep.	2	26	66	137	325	<1	<1	<1	1	3	<1	23	72	150	654	<1	23	87	220	744
Venezuela	5	39	77	127	303	4	26	50	93	229	7	21	52	106	452	4	20	40	75	196
Costa Rica	21	40	60	87	169	10	19	29	43	84	20	37	55	80	154	17	31	45	66	131
Colombia	5	25	51	85	202	3	16	35	59	150	4	15	34	67	271	2	12	23	40	111
Mexico	6	13	22	33	59	4	8	12	20	35	8	17	27	42	74	6	12	18	30	53
Barbados	<1	7	21	40	93	2	17	32	49	107	<1	<1	<1	<1	1	<1	8	25	63	190
Suriname	<1	7	15	27	59	<1	6	10	18	48	1	4	10	22	99	<1	5	8	14	45
Peru	7	14	22	33	61	4	7	11	15	25	<1	<1	1	3	7	<1	2	4	9	30
Ecuador	6	12	20	30	55	3	6	9	13	21	<1	<1	1	3	7	<1	2	4	8	27
Trinidad and Tobago	<1	3	7	15	31	<1	2	3	5	12	<1	1	5	14	46	<1	2	6	14	49
British Virgin Isl.	<1	<1	<1	<1	<1	<1	3	6	10	23	<1	3	11	29	111	<1	<1	<1	<1	<1
Puerto Rico	<1	<1	2	4	9	<1	<1	2	3	6	<1	<1	3	8	30	<1	<1	4	10	41
Bolivia	<1	<1	1	2	3	<1	<1	<1	<1	1	<1	<1	<1	<1	1	<1	<1	2	4	12
Panama	<1	<1	<1	3	20	<1	<1	<1	1	3	<1	<1	<1	2	6	<1	<1	<1	2	5
Cuba	<1	<1	<1	10	166	0	0	0	0	0	<1	<1	<1	<1	3	<1	<1	<1	6	62
St. Kitts and Nevis	<1	<1	<1	<1	<1	<1	<1	<1	4	31	<1	<1	<1	1	31	<1	<1	<1	<1	<1
Cayman Islands	<1	<1	<1	<1	2	<1	<1	<1	1	10	<1	<1	<1	<1	8	<1	<1	<1	2	21
Jamaica	<1	<1	<1	3	45	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	3
Bahamas	<1	<1	<1	<1	5	0	0	0	0	0	<1	<1	<1	5	99	<1	<1	<1	<1	3
Saint Lucia	<1	<1	<1	1	22	<1	<1	<1	<1	3	0	0	0	0	0	<1	<1	<1	<1	6
Argentina	<1	<1	<1	<1	13	<1	<1	<1	<1	7	<1	<1	<1	<1	2	<1	<1	<1	<1	3
Guatemala	<1	<1	<1	<1	<1	0	0	0	0	0	0	0	0	0	0	<1	<1	<1	<1	<1
Aruba	<1	<1	<1	<1	9	0	0	0	0	0	<1	<1	<1	<1	6	<1	<1	<1	<1	<1
Chile	<1	<1	<1	<1	5	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Anguilla	<1	<1	<1	<1	<1	0	0	0	0	0	<1	<1	<1	<1	9	0	0	0	0	0
St Vinc. and Gren.	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Honduras	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	<1	<1	<1	<1	<1
Guyana	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0	0	0	0	0	<1	<1	<1	<1	<1
Paraguay	0	0	0	0	0	<1	<1	<1	<1	<1	0	0	0	0	0	<1	<1	<1	<1	<1
Nicaragua	0	0	0	0	0	0	0	0	0	0	<1	<1	<1	<1	<1	0	0	0	0	0

Appendix D. Estimated distribution of dengue viremic person-days among travellers by country of departure from the Asian continent.

Country	Quarter 1 (January–March)					Quarter 2 (April–June)					Quarter 3 (July–September)					Quarter 4 (October–December)				
	Min	25%	Median	75%	Max	Min	25%	Median	75%	Max	Min	25%	Median	75%	Max	Min	25%	Median	75%	Max
Singapore	82	147	197	240	328	101	159	188	221	285	71	121	204	340	755	47	78	126	191	380
Thailand	15	35	51	72	141	35	92	121	171	328	72	145	210	328	1103	24	54	74	108	194
Malaysia	43	73	99	130	174	44	70	83	98	127	29	52	87	140	309	18	30	46	72	143
Maldives	3	23	61	119	257	<1	16	41	89	206	<1	24	43	68	122	6	41	67	99	146
India	<1	<1	6	35	172	<1	5	20	38	107	<1	12	31	65	156	<1	7	27	57	203
Viet Nam	1	4	5	7	12	3	8	13	19	34	9	17	28	46	150	3	6	9	12	22
Philippines	1	3	5	7	12	3	9	14	19	35	8	15	23	39	123	2	4	6	8	15
Indonesia	<1	3	8	14	35	<1	<1	3	6	15	<1	<1	<1	2	5	<1	1	2	4	7
Sri Lanka	<1	<1	<1	2	17	<1	<1	2	3	10	<1	2	4	7	19	<1	<1	2	4	19
Bangladesh	<1	<1	<1	<1	7	<1	<1	<1	1	4	<1	<1	2	3	7	<1	<1	<1	2	6
China	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Myanmar	<1	<1	<1	<1	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nepal	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

References

Almeida, A. P., Goncalves, Y. M., Novo, M. T., Sousa, C. A., Melim, M., Gracio, A. J., 2007. Vector monitoring of *Aedes aegypti* in the autonomous region of Madeira, Portugal. Euro Surveill. 12, E071115. Available online: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=3311.

Burke, D.S., Nisalak, A., Johnson, D.E., Scott, R.M., 1988. A prospective study of dengue infections in Bangkok. Am. J. Trop. Med. Hyg. 38, 172–180.

Dayal-Drager, R., 2004. Dengue fever. In: Heymann, D.L. (Ed.), Control of Communicable Disease Manual. InAPHA, Washington, pp. 146–152.

Department of Economic and Social Affairs — Population Division, 2005. World Population Prospects The 2004 Revision: Highlights. United Nations. Available at: http://www.un.org/esa/population/publications/WPP2004/2004Highlights_finalrevised.pdf.

Di Luca, M., Toma, L., Severini, F., D'Ancona, F., Romi, R., 2001. *Aedes albopictus* in Rome: monitoring in the 3-year period of 1998–2000. Ann. Ist. Super. Sanita 37, 249–254.

ECDC, Meeting Report: Consultation on chikungunya risk assessment for Europe — Stockholm, 30 March 2006, Stockholm, 2006.

Effler, P.V., Pang, L., Kitsutani, P., Vorndam, V., Nakata, M., Ayers, T., et al., 2005. Dengue fever, Hawaii, 2001–2002. Emerg. Infect. Dis. 11, 742–749.

Endy, T.P., Chunsuttiwat, S., Nisalak, A., Libraty, D.H., Green, S., Rothman, A.L., et al., 2002. Epidemiology of inapparent and symptomatic acute dengue virus infection: a prospective study of primary school children in Kamphaeng Phet. Thailand. Am. J. Epidemiol. 156, 40–51.

Gould, L.H., Osman, M.S., Farnon, E.C., Griffith, K.S., Godsey, M.S., Karch, S., et al., 2008. An outbreak of yellow fever with concurrent chikungunya virus transmission in South Kordofan, Sudan, 2005. Trans. R. Soc. Trop. Med. Hyg. 102, 1247–1254.

Gratz, N.G., 2004. Critical review of the vector status of *Aedes albopictus*. Med. Vet. Entomol. 18, 215–227.

Gravier, P., Martin, R., Boniface, F., Tolou, H., Grandadam, M., 2007. Gabon: it's Chikungunya. Med. Trop. (Mars). 67, 215.

Gubler, D.J., Suharyono, W., Tan, R., Abidin, M., Sie, A., 1981. Viraemia in patients with naturally acquired dengue infection. Bull. World Health Organ. 59, 623–630.

Laras, K., Sukri, N.C., Larasati, R.P., Bangs, M.J., Kosim, R., Djauzi, et al., 2005. Tracking the re-emergence of epidemic chikungunya virus in Indonesia. Trans. R. Soc. Trop. Med. Hyg. 99, 128–141.

Massad, E., Wilder-Smith, A., 2009. Risk estimates of dengue in travelers to dengue endemic areas using mathematical models. J. Travel Med. 16, 191–193.

Massad, E., Ma, S., Burattini, M.N., Tun, Y., Coutinho, F.A., Ang, L.W., 2008. The risk of chikungunya fever in a dengue-endemic area. J. Travel Med. 15, 147–155.

Mavalankar, D., Shastri, P., Raman, P., 2007. Chikungunya epidemic in India: a major public-health disaster. Lancet Infect. Dis. 7, 306–307.

Michault, A., 1998. Insularity and epidemic risks in Reunion. Bull. Soc. Pathol. Exot. 91, 52–55.

Perrau, J., Catteau, C., Michault, A., Parain, C., Favier, F., 2007. Fin 2006, 300 000 personnes avaient été atteintes par le chikungunya. Economie de La Réunion 129, 16–17.
Peyrefitte, C.N., Rousset, D., Pastorino, B.A., Pouillot, R., Bessaud, M., Tock, F., et al., 2007. Chikungunya virus, Cameroon, 2006. Emerg. Infect. Dis. 13, 768–771.
Porter, K.R., Beckett, C.G., Kosasih, H., Tan, R.I., Alisjahbana, B., Rudiman, P.I., et al., 2005. Epidemiology of dengue and dengue hemorrhagic fever in a cohort of adults living in Bandung, West Java, Indonesia. Am. J. Trop. Med. Hyg. 72, 60–66.
ProMED-mail, 18-12-2008. Chikungunya (03) — Singapore. ProMED-mail. 20080118. 0220. Available at: http://www.promedmail.org.
Ramchurn, S.K., Goorah, S.S.D., Mungla, D., Ramsurrun, B., Pydiah, V., Summun, A., 2008. A study of the 2006 Chikungunya epidemic outbreak in Mauritius. Internet Journal of Medicine Update 3, 11–21.
Ravi, V., 2006. Re-emergence of chikungunya virus in India. Indian J. Med. Microbiol. 24, 83–84.
Renault, P., Solet, J.L., Sissoko, D., Balleydier, E., Larrieu, S., Filleul, L., et al., 2007. A major epidemic of chikungunya virus infection on Reunion Island, France, 2005–2006. Am. J. Trop. Med. Hyg. 77, 727–731.
Rezza, G., Nicoletti, L., Angelini, R., Romi, R., Finarelli, A.C., Panning, M., et al., 2007. Infection with chikungunya virus in Italy: an outbreak in a temperate region. Lancet 370, 1840–1846.
Rigau-Perez, J.G., Clark, G.G., Gubler, D.J., Reiter, P., Sanders, E.J., Vorndam, A.V., 1998. Dengue and dengue haemorrhagic fever. Lancet 352, 971–977.
Rosen, L., 1986. Dengue in Greece in 1927 and 1928 and the pathogenesis of dengue hemorrhagic fever: new data and a different conclusion. Am. J. Trop. Med. Hyg. 35, 642–653.
Scholte, E.J., Schaffner, F., 2007. Waiting for the tiger: establishment and spread of the *Aedes albopictus* mosquito in Europe. In: Takken, W., Knols, B.G.J. (Eds.), Emerging pests and vector-borne disease in Europe. InWageningen Academic Publishers, Wageningen, pp. 241–260.
Schwartz, E., Weld, L.H., Wilder-Smith, A., von, S.F., Keystone, J.S., Kain, K.C., et al., 2008. Seasonality, annual trends, and characteristics of dengue among ill returned travelers, 1997–2006. Emerg. Infect. Dis. 14, 1081–1088.
Sergon, K., Yahaya, A.A., Brown, J., Bedja, S.A., Mlindasse, M., Agata, N., et al., 2007. Seroprevalence of Chikungunya virus infection on Grande Comore Island, union of the Comoros, 2005. Am. J. Trop. Med. Hyg. 76, 1189–1193.
Sergon, K., Njuguna, C., Kalani, R., Ofula, V., Onyango, C., Konongoi, L.S., et al., 2008. Seroprevalence of Chikungunya Virus (CHIKV) Infection on Lamu Island, Kenya, October 2004. Am. J. Trop. Med. Hyg. 78, 333–337.
Shope, R., Mackenzie, J., 2004. Arthropod-borne viral arthritis and rash. In: Heymann, D.L. (Ed.), Control of Communicable Diseases Manual. InAPHA, Washington, pp. 35–37.
Sissoko, D., Malvy, D., Giry, C., Delmas, G., Paquet, C., Gabrie, P., et al., 2008. Outbreak of Chikungunya fever in Mayotte, Comoros archipelago, 2005–2006. Trans. R. Soc. Trop. Med Hyg. 102, 780–786.
Soon, Y.Y., Junaidi, I., Kumarasamy, V., Chem, Y.K., Juliana, R., Chua, K.B., 2007. Chikungunya virus of Central/East African genotype detected in Malaysia. Med. J. Malaysia 62, 214–217.
Toma, L., Severini, F., Di, L.M., Bella, A., Romi, R., 2003. Seasonal patterns of oviposition and egg hatching rate of *Aedes albopictus* in Rome. J. Am. Mosq. Control Assoc. 19, 19–22.
Tsetsarkin, K.A., Vanlandingham, D.L., McGee, C.E., Higgs, S., 2007. A single mutation in chikungunya virus affects vector specificity and epidemic potential. PLoS Pathog. 3, e201.
Vaughn, D.W., Green, S., Kalayanarooj, S., Innis, B.L., Nimmannitya, S., Suntayakorn, S., et al., 1997. Dengue in the early febrile phase: viremia and antibody responses. J. Infect. Dis. 176, 322–330.
WHO, 2007. Outbreak and spread of chikungunya. Wkly. Epidemiol. Rec. 82, 409–415. Available online: http://www.who.int/wer/2007/wer8247.pdf.