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Access to yellow fever travel vaccination centres in England, Wales, and Northern Ireland: A geographical study

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ABSTRACT

Background: More than 700,000 trips were made by residents in England, Wales, and Northern Ireland (EWNI) in 2015 to tropical countries endemic for yellow fever, a potentially deadly, yet vaccine-preventable disease transmitted by mosquitoes. The aim of this study was to map the geographical accessibility of yellow fever vaccination centres (YFVC) in EWNI.
Methods: The location of 3208 YFVC were geocoded and the average geodetic distance to nearest YFVC was calculated for each population unit. Data on trips abroad and centres were obtained regionally for EWNI and nationally for the World Top20 countries in terms of travel.
Results: The mean distance to nearest YFVC was 2.4 km and only 1% of the population had to travel more than 16.1 km to their nearest centre. The number of vaccines administered regionally in EWNI was found correlated with the number of trips to yellow fever countries. The number of centres per 100,000 trips was 6.1 in EWNI, which was below United States (12.1) and above the rest of Top20 countries.
Conclusions: The service availability was in line with demand regionally. With the exception of remote, rural areas, yellow fever vaccination services were widely available with only short distances to cover for the travelling public.

1. Introduction

The populations of England, Wales, and Northern Ireland made more than 60 million trips abroad in 2015 [1]. More than 700,000 of these trips were made to countries endemic for yellow fever, a potentially deadly, tropical disease transmitted by mosquitoes. The disease is preventable by vaccination and this study was undertaken to elucidate the geographical accessibility of yellow fever vaccination centres.

Yellow fever control has been on the international public health agenda since 1851 and has remained a disease under tight international surveillance and control measures ever since together with diseases such as cholera, and pneumonic plague [2]. Due to its reservoir in monkey and other non-human primate populations in the rain forests of Africa and South America (the forest cycle is maintained with tree-living mosquitoes as vectors), yellow fever may never be eradicated [3]. The main control measure for yellow fever is therefore vaccination in combination with vector control in high risk areas as well as measures available to countries at risk of importing or exporting the disease such as vaccination certificate requirements, border vaccination, and emergency quarantine restrictions to reduce the international spread of the disease [2,4,5].

Occasionally, there are large outbreaks in urban areas (urban cycle), where the transmission depends on the *Aedes aegypti* mosquito, which has spread in cities across the tropics in recent decades. A yellow fever outbreak in Angola and Democratic of Republic of Congo (DRC) in 2015–2016 with more than 7000 suspected cases (965 confirmed cases and 137 confirmed deaths) was a stark reminder of the emerging threat of urban yellow fever outbreaks [6,7]. Increased international travel, urbanisation, and the fact that many tropical countries have large unvaccinated populations make the prospects of new urban yellow fever outbreaks a particular concern. At least 42 cases of international spread were recorded in connection with the Angola-DRC outbreak to countries with vector presence and largely unvaccinated populations including China and Kenya [8].

Despite vector control efforts and vaccination campaigns, large, cyclical sylvatic outbreaks continue to affect some countries [9]. In

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early 2017, a sylvatic outbreak in Brazil spread into states where transmission is rarely or not previously reported. As of 31 May 2017, a total of 792 confirmed cases with 274 confirmed deaths had been reported [10]. A mass vaccination programmes was set up to stop the spread into cities. A move that has been seen against the back cloth of recent large urban outbreaks of similar mosquito-borne diseases in Brazil, i.e. chikungunya, dengue, and Zika virus [9].

The National Travel Health Network and Centre (NaTHNaC) has overseen the registration, training, clinical standards, and audit of yellow fever vaccination centres in England, Wales, and Northern Ireland in compliance with the International Health Regulations for yellow fever since 2005 [11] and this is the first study to evaluate the geographical accessibility [12] of the yellow fever vaccination services. The aims of the study were thus to map and ascertain the geographical accessibility of yellow fever vaccination centres, match the number of trips to countries with yellow fever risk to the number of vaccinations given per region, identify any underserved populations and evaluate any need to regulate service provision, and gather data to support contingency planning in the event of a vaccine shortage.

2. Methods

Administrative data on the postcode location of yellow fever vaccination centres were extracted from the Yellow Fever Vaccination Programme database (NaTHNaC, 27 October 2016). Occupational Health departments (N = 218) were excluded as these by definition were not open to the general public. A total of 3222 centres were registered. General practitioner (GP) practices were the most frequent type of centre (N = 2381). Of the 3222 centres, 3208 or 99.6% could be geo-located to Census 2011 lower layer super output area (super output area for Northern Ireland; this is the nearest equivalent unit and it will be referred to as lower layer super output area hereinafter) and UK Region using the Office for National Statistics (ONS) Postcode Directory, August 2016 [13]. The lower layer super output area unit is the finest geographical unit for census data release in the UK that has been optimised to be homogenous with regards to population size and socio-economic characteristics. The latest mid-year population estimates (2015) were obtained at lower layer super output area level from ONS [14] and the Northern Ireland Statistics and Research Agency (NISRA) [15]. The analyses were conducted at lower layer super output area (N = 35,643), which had a mean (SD) population of 1676 (379). The average geodetic distance (crow-fly distance) from each population unit was calculated to each centre location using the Stata module, GEODIST [16] to determine the distance to the nearest centre at lower layer super output area level. The centres were assigned to distance categories according to the following population percentiles: 75th, 90th, 95th, and 99th. Data on the average number of vaccinations per centre across regions were obtained from annual surveys of the centres in 2013–2015 (NaTHNaC, unpublished data). Boundary data for Census output areas, UK Regions and countries were obtained from the UK Data Service/Edinburgh University Data Library [17], which contains National Statistics data (© Crown copyright and database right, 2016), NRS data (© Crown copyright and database right, 2016, Source: NISRA Website, www.nisra.gov.uk; accessed 17 November 2016), and OS data (© Crown copyright and database right, 2016). Boundary data for the Isle of Man, Republic of Ireland, and Scotland were obtained from Natural Earth (www.naturalearthdata.com; accessed 17 November 2016). Maps were created using Quantum GIS 2.12 [18]. Data on trips abroad by UK region of residence undertaken in 2015 were obtained from ONS Social Surveys (Crown copyright; December 2016). Data on trips abroad by countries where the traveller spent most time and UK Region of residence were obtained from Office for National Statistics [1]. Data on countries with risk of yellow fever transmission were obtained from the World Health Organization [19]. Data on the number of registered yellow fever vaccination centres in other countries were obtained from ministries of health websites, literature, and personal communication with health professionals (see references at Table 4). The numbers of trips abroad (departures) by country in 2013 (N = 100) were obtained from the World Bank data repository [20]. Data analyses were carried out in Stata 14 [21].

3. Results

The population weighted mean distance to nearest centre varied from 0.6 km in London to 7.1 km in Northern Ireland. The national mean distance was 2.4 km and the maximum distance 30.9 km. Only 1% of the general population had more than 16.1 km to their nearest centre (99th percentile) (Table 1, Fig. 1, Fig. 2).

A total of 713,548 trips to countries with yellow fever transmission risk were made by residents in England, Wales, and Northern Ireland in 2015 (Table 2). Nigeria (20.7%), Brazil (14.8%), and Kenya (13.8%) alone accounted for half of all trips and the ten most commonly visited countries combined accounted for 84.3% of all trips (Table 2).

The number of centres by UK Region varied from 51 in Northern Ireland to 858 in London. The number of centres per population varied from 2.8 per 100,000 population in Northern Ireland to 9.9 per 100,000 population in London. Nationally, there were 5.4 centres per 100,000 population (Table 3).

The size of the centres in terms of the yearly number of vaccines administered was calculated from data submitted in annual surveys in 2013–2015. The average number nationally was 40 vaccines per centre. The London average was the highest at 59 vaccines per centre followed by Northern Ireland (45), South East (40), North West (38), North East (38), East of England (34), South West (34), Yorkshire and The Humber (29), West Midlands (28), Wales (27) and East Midlands (25).

There was a linear relationship between the estimated number of yellow fever vaccines administered and the number of trips to countries with yellow fever risk by UK Region, which indicate that there is balance between supply and demand at the regional level (Fig. 3).

The number of centres per 100,000 international trips abroad was 6.1 in England, Wales, and Northern Ireland, which was below that of United States (12.1) and above the rest of World Top20 countries in terms of trips abroad (Table 4).

Table 1
Distance to nearest yellow fever vaccination centre for the general population by UK Region (km).

Region	Min	Median	Mean	p75	p99	Max
North East	0.0	2.1	3.2	3.8	20.2	28.3
North West	0.0	1.6	2.0	2.7	8.7	25.0
Yorkshire & The Humber	0.0	1.7	2.4	3.3	10.6	26.4
East Midlands	0.0	1.7	2.7	3.5	15.9	21.9
West Midlands	0.0	1.5	2.1	2.5	11.5	17.3
East of England	0.0	1.5	2.8	3.6	14.6	20.9
London	0.0	0.5	0.6	0.8	2.2	4.0
South East	0.0	1.2	1.9	2.4	9.6	18.7
South West	0.0	1.5	2.7	3.7	14.3	23.7
Northern Ireland	0.0	3.9	7.1	11.9	26.4	30.9
Wales	0.0	3.2	4.9	7.5	22.0	29.3
Total	0.0	1.3	2.4	2.9	16.1	30.9

Note: The national 56th percentile was 1.6 km. The headers, p75 and p99, denote the 75th and 99th percentile, respectively.