Illegal import of bushmeat and other meat products into Switzerland on commercial passenger flights

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Summary

Illegal imports of meat can present substantial risks to public and animal health. Several European countries have reported considerable quantities of meat imported on commercial passenger flights. The objective of this study was to estimate the quantity of meat illegally imported into Switzerland, with a separate estimation for bushmeat. Data were obtained by participation in intervention exercises at Swiss international airports and by analysing data on seizures during the four-year period 2008 to 2011. The study revealed that a wide array of animal species was imported into Switzerland. From the database, the average annual weight of meat seized during the period analysed was 5.5 tonnes, of which 1.4% was bushmeat. However, in a stochastic

model the total annual inflow of illegal meat imports was estimated at 1,013 tonnes (95% CI 226 to 4,192) for meat and 8.6 tonnes (95% CI 0.8 to 68.8) for bushmeat. Thus, even for a small European country such as Switzerland the quantities of illegally imported meat and meat products are substantial and the consequences for public and animal health could be high. To reduce the risk, it is essential that surveillance at European airports is harmonised and that passenger information campaigns clarify the consequences of the illegal import of meat, particularly bushmeat.

Keywords

Biological hazard – Bushmeat – Commercial passenger flight – Illegal import – Stochastic model – Switzerland.

Introduction

Illegal import of meat and meat products can pose a substantial risk to animal and human health (1). Outbreaks of foot and mouth disease, African swine fever, classical swine fever and swine vesicular disease in countries formerly free from these infections have been attributed to the feeding of waste meat (swill) to domestic pigs (2, 3, 4, 5). These diseases can be associated with significant economic and social costs, as well as severe trade limitations in the livestock sector. Illegally imported meat is also a potential threat to human health, particularly when the meat is from wild animals originating from Africa, Asia, and Central or South America; such meat is commonly referred to as bushmeat (6). Approximately 75% of emerging diseases are zoonoses and one of the activities that could result in the emergence of such diseases is the bushmeat trade (7).

Wild animals are a large and unknown reservoir of zoonotic and non-zoonotic disease agents (7, 8, 9). Animal species hunted as bushmeat include non-human primates (e.g. chimpanzee, *Pan troglodytes*; orangutan, *Pongo pygmaeus*; red colobus monkeys, *Procolobus tephrosceles*), wild herbivores (e.g. duikers, *Cephalophus maxwellii*; forest elephants, *Loxodonta cyclotis*; porcupines, *Atherurus africanus, A. macrourus*), wild cats (e.g. leopards, *Panthera pardus*) and reptiles

(e.g. snakes, *Serpentes;* crocodiles, *Crocodylidae*; tortoises, *Testudinidae*). Several of these species are animals near extinction and are named on the Convention on International Trade in Endangered Species (CITES) list (10, 11). Non-human primates pose a higher risk for transmission of zoonotic pathogens because their physiological similarities to humans enable more efficient transfer of such agents (7, 12). Of particular public health importance is the frequent absence of veterinary monitoring of animals from which the bushmeat is derived (13). In addition, a poor level of hygiene is often the norm during the killing, butchering and preparation of animals in some countries of origin. Furthermore, a poor or even non-existent cool chain during transportation from the country of origin to the importing country again increases the probability of high levels of pathogens in the meat tissue (13). Outbreaks of Ebola (12, 14, 15), simian foamy virus (7) and monkeypox (16, 17) have been attributed to consumption of bushmeat. The severe acute respiratory syndrome (SARS) virus in humans was acquired through consumption of small carnivores such as civets and wild cats in China (17, 18). It is also thought that the human immunodeficiency virus (HIV) mutated from simian immunodeficiency virus (SIV), which is found in chimpanzees, after the consumption of such meat in Africa (16, 19).

Migrant human populations living in Europe are an important market for wild animal meat from their home countries because they are willing to pay more for bushmeat than they would for meat from domestic animal species (20, 21, 22, 23). There are several reasons for this: bushmeat is considered a delicacy and adds variety to their diet, it is prestigious and plays an important role in ceremonies such as weddings and other festivals, it serves as a reminder of their culture and it is a way for these communities to connect with the village life that they left behind in Africa or Asia (20, 21, 22). It is estimated that close to one million wild animals, such as antelopes, bush-pigs and rodents, among others, are killed and eaten annually in Africa alone (24). The economic gains from the bushmeat trade in West and Central Africa are reported to be significant, with an annual revenue close to US$50 million (8).

In a recent study at Roissy-Charles de Gaulle airport in Paris, the luggage of passengers was searched for illegally imported bushmeat during a 17-day period, with the result that the estimated annual amount of such meat in passenger luggage was approximately 270 tonnes (t) (25). A similar study at airports in the United Kingdom (UK) during an eight-month period in 2000 revealed that 5.5 t of bushmeat and fish were transported in passenger luggage on 14 flights from Africa (26). The annual weight of meat illegally imported into the UK is estimated at approximately 11,875 t (1). It is expected that a similar inflow of bushmeat passes through other major European Union (EU) airports such as Amsterdam, Frankfurt and Lisbon (9).

In a risk assessment in Switzerland in 2006, the median annual inflow of meat and meat products illegally imported from abroad was estimated to be 2,500 t (min. 240 to max. 35,000), using import routes of road and air freight, private road travel and commercial passenger flights (27). The estimate was based on retrospective data on seizures by customs officials during a single year, but made no distinction between domestic meat and bushmeat. However, this distinction is of major importance in assessing the risk to animal and human health from imports of illegal meat.

The aim of the present study was to estimate the quantity, origin and type of illegal meat being imported into the major Swiss international airports from Eastern Europe (from those countries where meat imports are illegal) and from non-European countries. Specific objectives were:

a) to analyse existing data on meat products seized during routine customs inspections in the period 2008 to 2011,

b) to estimate the total annual weight of illegally imported meat and meat products using a stochastic model and

c) to undertake specific intervention exercises in order to validate the probability of passengers' luggage being searched on entry into Switzerland at the two airports used in the model.

The results of the study will serve as a basis for assessing the risk of introducing exotic animal diseases and zoonoses into Switzerland and for developing appropriate procedures for risk management.

Methodology

Analysis of data from routine customs inspections

The authors obtained the study database from the airport customs offices in Zurich and Geneva, the only Swiss airports with border veterinary inspection services. These airports handle 86% of all flights at national airports in Switzerland (28). The database comprised records of seizures of animal origin, including diverse meat products, and spanned the periods August 2008 to the end of September 2011 (38 months) at Zurich and May 2008 to mid-October 2011 (42 months) at Geneva. Systematic electronic registration of seizures of animal products was introduced in 2008. For every seizure, an entry in the database specified the date of the seizure, flight number of the passenger, description of the product (including animal species and method of processing the meat for some seizures), country of origin, weight in kg and the point of entry into Switzerland (Zurich or Geneva). The customs officials identified the species according to information provided by the passenger or by checking the packaging of the confiscated item.

The software R (http://cran.r-project.org/) was used for assessment of data quality, categorisation of new variables and statistical analysis. The product description was a free text variable that was summarised into the following categories: meat (separate category for sausage), fish and seafood, milk products, egg products, honey, insects, and others (containing non-animal products, feathers, birds' nests, unspecified child nutrition, ready meals). If records met any one of the following criteria, the food product was defined as bushmeat:

– the meat was described as 'bushmeat'

– the information stated that the meat originated from non-specified game animals

– the meat was described as having originated from identified wildlife species

– the description stated that the meat products were ‘African’ or ‘Asian’

– the record described the food item as an ‘animal product’ from an Asian or sub-Saharan country, without further specification

– the food was identified as biltong (cured meat from South Africa).

The countries of origin were grouped into geographical regions: North Africa, Eastern Africa, Southern Africa, West and Central Africa, Asia, Middle East, North America, South/Central America and the Caribbean, Eastern Europe, and Oceania. Each of the confiscated meat products was further categorised according to animal species: cattle, swine, small ruminants, horse, birds (including chicken), rodents, fish, caviar, seafood, snail, antelope, kangaroo, ape, porcupine, armadillo, unspecified game animals and unidentified animal species. The meat was identified as either fresh or processed, and the processed meat was further categorised according to the processing method: frozen, salted, dried, smoked, cooked, grilled, fried or canned. To determine the average annual number of seized products, the numbers of confiscated items from Zurich and Geneva were divided by the period of data collection on a yearly scale (i.e. by 38/12 for Zurich and 42/12 for Geneva).

Estimation of the annual quantity of illegally imported meat and bushmeat

A scenario tree was generated for a stochastic model developed in 2006 for the estimation of illegal imports into Switzerland (27). The model was modified for the purposes of the present study, as described below, and was run in Microsoft Excel with the add-on Palisade @RISK (www.palisade.com). The meat was categorised as bushmeat or meat from domestic species (Fig. 1). The data needed as input for the model were derived either from national statistics on air travel, the database on seizures from the airport customs offices, or from expert opinion (Table I). Because only a very limited number of

experts with sufficient knowledge on the topic were available, expert opinion was derived from informal interviews rather than from a standardised questionnaire. At each airport, the head of the customs office was asked to provide estimates of the proportion of passengers who do not declare anything and the proportion of passengers whose luggage is searched.

Step one

The annual number of meat and bushmeat imports was estimated by multiplying the probability of an illegal import by the number of passengers entering Switzerland through the airports at Zurich and Geneva. The same probability of carrying meat was assumed for passengers whose luggage was searched by customs officials and those whose luggage was not searched. The frequencies of illegal imports of meat (nIllegalMeat) and bushmeat (nIllegalBm) are given by:

nIllegalMeat = *Npass* × P1 × P2 × P3 × P4 × (1-P5) and

nIllegalBm = *Npass* × P1 × P2 × P3 × P4 × P5,

where *Npass* is the total number of passengers entering Switzerland via the airports at Zurich and Geneva and P1 to P5 denote probability distributions of the different steps of the scenario tree (Fig. 1, Table I).

Step two

The annual numbers and weights of illegally imported meat and meat products were estimated per geographical region of origin, with separate calculations for bushmeat. As the number of illegally imported meat products that are confiscated is small compared with the total number of passengers entering Switzerland, the data were subjected to a Poisson distribution to simulate the variability and uncertainty of the observed number of illegal imports (for meat and bushmeat separately) per region. For East Africa, no bushmeat import was recorded during the period of the dataset, although bushmeat import from this region is possible in principle. Zero imports were

therefore not assumed and an estimate of 0.25 illegal imports per year was used for the modelling.

Step three

The distribution of the number of illegal imports of meat and bushmeat per region was calculated by multiplying the proportions of imports from the respective regions by the annual number of illegal meat (nIllegalMeat) and bushmeat (nIllegalBm) imports. The weight distributions of the meat and meat product imports were fitted using @RISK on the registered weights of the confiscated meat products (information on the weight was missing for only 5% of meat imports) and the distribution with the smallest Anderson–Darling (A–D) and Kolmogorov–Smirnov (K–S) value was chosen. The meat weights were consequently described as a truncated (0.1 kg to 50 kg) lognormal distribution with a mean of 3.38 and a standard deviation of 3.30 (RiskLognorm(3.38;3.30;RiskShift(-0.0738); RiskTruncate(0.1;50); A–D value = 4.74, K–S value = 0.045).

Step four

The total weight of illegally imported meat and meat products per region was estimated by multiplying the number of illegal meat imports per region and a sample drawn from the weight distribution of meat imports. The same procedure was used for bushmeat. Because the weights of the bushmeat products (a total of 30 bushmeat items were imported during the study period) did not follow a continuous distribution, they were described as a discrete distribution in ten categories (kg): 0 to1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 8, 8 to 11, 11 to 20, 20 to 30 and 30 to 50, with probabilities of 0.1, 0.133, 0.133, 0.066, 0.2, 0.033, 0.1, 0.1, 0.1 and 0.033. A uniform distribution was assumed within each category. The model was simulated for 50,000 iterations. Factors with the greatest influence on the total quantity of imported meat and bushmeat in the model were determined in an advanced sensitivity analysis in @RISK, considering the six variables of Table I as input parameters and using 10,000 iterations.

Intervention exercises

Discrete exercises in the seizure of illegal meat imports were held on a single working day at Zurich airport in September 2011 and Geneva in October 2011, using an increased number and intensity of luggage searches. The customs team was reinforced by the research team of this study, who worked alongside the customs officers in each airport. Direct and transit flights from the regions of interest in Africa, Asia and South America, where bushmeat imports are suspected to come from, were selected in advance by customs officers. As the passengers exited the terminal they were selected by the customs officer according to the targeted regions. There were two procedures for inspecting luggage: either *(i*) passengers were selected based on the customs officer's suspicion and asked to open their suitcases for inspection or *(ii*) the suitcases were initially scanned in the airport X-ray machine and opened if suspicious products were detected. The X-ray machines operate at between 85% and 100% efficiency (personal communication from the customs department at Geneva airport).

The proportion of the number of seizures of animal products on the day of intervention (n_seizures_intervention) in relation to the estimated total number of passengers on that day at that airport (n_passengers_intervention) was compared with the proportion of the annual number of seizures in the database (n_annual_seizures) among the estimated annual number of passengers during the period for which records from routine inspections were available (*Npass*). Expression of n_seizures_intervention as a beta distribution and n_annual_seizures and *Npass* as PERT distributions (see Table I) resulted in an estimation of how much more intensive the searches were during the days of intervention (*int*):

$$int = \frac{\text{n\_seizures\_intervention}/\text{n\_passengers\_intervention}}{\text{n\_annual\_seizures}/Npass}.$$

The database on seizures contained information on the number of seizures but not on the number of luggage searches, therefore the proportion of passengers whose luggage was searched during one year was estimated as follows:

$$\text{percentage of checked passengers} = \frac{number\ of\ passengers\ checked\ per\ year}{Npass} =$$

$$\frac{number\ of\ checked\ passengers\ on\ the\ intervention\ days \times \frac{365}{int}}{Npass}$$

The percentage of passengers whose luggage was searched per airport was defined as output in the @RISK model, which was run for 50,000 iterations.

Results

Description of animal products confiscated during routine customs inspections

During the periods of data collection, a total of 8,633 seizures were recorded: 7,924 (91.8%) in Zurich and 709 (8.2%) in Geneva. Items were imported singly or in different combinations. The imported product was meat in 5,808 (67.3%) entries, among which were 2,810 (48.4%) seizures of sausage. Other imported products were fish and seafood (n = 694), milk products (n = 3,215), eggs (n = 42), honey (n = 25), insects (n = 5) and other products (n = 11). The category could not be specified for seven of the seizures because of missing or incomplete information. Thirty counts of clearly definable bushmeat (0.5% of the meat products) were registered.

The total weight of registered illegal meat, including bushmeat, entering Switzerland during the collection periods of 42 and 38 months at the two airports was 18,350 kg, resulting in annual seizure weights of 720 kg and 4,920 kg at Geneva and Zurich respectively. Regions of Eastern Europe, South and Central America, the Caribbean and the Middle East were the main contributors to the total quantity of imported meat (Table II, Fig. 2). More than 25% of the intercepted meat originated from Kosovo alone, followed by Brazil (8.8%), the

Dominican Republic (8.4%), Serbia (8.4%), Turkey (7.8%) and Macedonia (7.3%). The country of origin was not indicated in five entries and could not be identified in 17 imports because of unknown country abbreviations and flight numbers. The species from which the meat was derived was registered in only 18% of all the meat products in the dataset: among them were birds, including chicken (38%), cattle (37%), swine (11%), small ruminants (11%) and others, i.e. horse, rodents, kangaroo (3%). Fresh meat constituted 18% of seized imports. Types of meat processing were: drying (65%), canning (10%), other methods such as smoking, boiling, salting, grilling and frying (6%), and freezing (1%). However, processing methods were recorded in only 18% of all meat imports.

During the study period the total weight of clearly recognised bushmeat that was seized was 249 kg (1.4% of the total weight of illegal meat imports). West Africa (including Cameroon, Côte d'Ivoire, Benin, Ghana) was the greatest contributor to bushmeat imports into Switzerland (Table III). Cameroon alone contributed 57% of the bushmeat during the period of observation. The bushmeat often came in relatively large quantities: the median weight of the confiscated bushmeat imports was 4.5 kg (interquartile range [IQR] 2 to 10), whereas other meat imports had a median weight of 2.3 kg (IQR 1.3 to 4). The processing methods for bushmeat were known for only two imports: one was fresh bushmeat from Cameroon and the other was dried meat from South Africa. The species from which the meat was derived was recorded for 60% of seizures and included diverse groups such as primates, ruminants, rodents (mainly porcupines) and unspecified game animals (Table III).

Estimation of the annual quantity of illegally imported meat and bushmeat

The estimated median annual number of illegally imported meat and meat products (excluding bushmeat) was 432,876 (95% confidence interval [CI] 272,586 to 678,112). The median annual number of imported bushmeat products was 2,130 (95% CI 1,287 to 3,476). The estimated median annual weight of illegal meat and meat product

imports was 1,013 t (95% CI 166 to 5,494) and for bushmeat 8.6 t (95% CI 0.5 to 88.5) (Table IV).

According to the sensitivity analysis, the probability that a passenger whose luggage was searched was importing an animal product (P3), the probability that the imported animal product was meat (P4) and the annual number of passengers entering Switzerland (*Npass*) had the greatest influence on the annual quantity of illegally imported meat (Fig. 3a). For bushmeat similarly, P3, P4 and *Npass*, together with the probability that the imported meat was bushmeat (P5), were the parameters with the greatest influence (Fig. 3b).

Results of the intervention exercises

According to Swiss air travel statistics for 2011, the average numbers of passengers per day passing through Swiss airports were 30,000 at Zurich and 15,500 at Geneva. On the days of the intervention exercises the numbers were 34,000 in Zurich and 8,200 in Geneva (personal communication from the Swiss Federal Office of Statistics). The luggage of 242 passengers (127 in Zurich, 115 in Geneva) was searched by customs officers. Passengers from regions of interest flying into Switzerland via other European cities were targeted: Paris (Air France), London (British Airways), Amsterdam (KLM Royal Dutch Airlines), Lisbon (Air Portugal), Brussels (SN Brussels Airlines), Dubai (airlines of the United Arab Emirates), Nairobi (Swiss Air), Yaoundé (Swiss Air) and Moscow (Aeroflot).

In the intervention exercises, the proportion of searched luggage in Geneva (1.4%) was 3.8 times higher than in Zurich (0.4%). Comparison of the average annual number of confiscations with the percentage of confiscated meat imports per incoming passenger on the dates of the intervention exercises revealed that searches increased 1.8-fold at Zurich (95% CI 1.0 to 2.8) and 12.4-fold at Geneva (95% CI 3.7 to 29.2). In Geneva, X-ray screening of luggage identified a total of 45 passengers who were transporting suspicious meat imports and these persons were subsequently asked to open their luggage for a detailed hand search. In Zurich, the majority of the 127 passengers included in the intervention exercise had to open their luggage without

previous X-ray baggage scanning. In Geneva, three meat imports with a total weight of 4.3 kg were seized and in Zurich 13 meat imports with a total weight of 26 kg were seized.

The greatest contributors to meat imports during these two days were Asian countries (China, Thailand, Korea, Singapore), making a contribution of 53% of the total inflow of illegal meat into Switzerland, followed by Turkey at 13% and Brazil at 7%. At Geneva airport, two of the three seizures originated from African countries. Among the imported meat products were dried meat (35%), fresh meat (7%) and canned meat (7%). The animal species of origin most frequently imported were cattle (53%), followed by swine (33%) and birds (14%). No bushmeat was confiscated during these two days. When a passenger was found not to be importing meat, no personal information was recorded.

From the data collected on the intervention days, the annual proportion of searched luggage among the total number of passengers entering Switzerland was estimated at 0.24% (95% CI 0.15 to 0.43) for Zurich and 0.06% (95% CI 0.03 to 0.20) for Geneva. These percentages were 2.1 and 5.4 times lower for Zurich and Geneva, respectively, than the probability (P2) included in the model based on the opinions of customs officers (Table I).

Discussion

This study provides an estimate of the quantity of illegal meat and meat products, including bushmeat, transported into Switzerland on commercial passenger flights, as has been described for other European countries (25). The main countries contributing to the illegal entry of meat were identified. Only a small percentage of illegal meat imports were seized by customs; the total annual quantity of non-intercepted incoming meat and meat products was estimated to be 8.6 t for bushmeat and 1,013 t for other meat.

The study revealed that the total quantity of clearly identified illegal bushmeat was small compared with the total quantity of non-bushmeat products. However, there was a substantial potential for bias in the

classification of meat as bushmeat or meat from domestic animals because the customs officers at Swiss international airports depend on information provided by passengers. Illegal meat imports are frequently dressed, smoked or processed in ways that make it impossible to identify the species from which the meat could have been derived by mere superficial examination of the product (personal communication from customs officers). In such situations, the customs department categorised meat products as being from undefined animal species and the products were not considered as bushmeat in the study. The dataset included many undefined animal species (approximately 80%). Similarly, it can be expected that there was misclassification of species; for example, antelope meat was documented as originating from Colombia (Table III), whereas it is known that there are no antelopes in that country. On the other hand, registered meat products that included the specification 'African' or 'Asian' were categorised as bushmeat even if the species was unknown. A study to determine which species are at highest risk regarding bushmeat imports into Switzerland is in progress. DNA analysis of samples collected at the two airports will result in a better understanding of species at risk and potential diseases of concern.

A further reason for the seemingly low number of bushmeat imports is that there are few direct flights into Switzerland from Asian and sub-Saharan African countries, the main contributors to bushmeat imports (29). Many passengers travel via a major European airport such as Paris, Amsterdam, Brussels or London before coming into Switzerland on a transit flight or by another route. For this reason, the number of bushmeat imports via air travel is expected to be limited and the greatest inflow of meat imports into Switzerland is most probably by ship and road, which were not considered in this study. In addition, the weight of meat per import by air freight is expected to be much higher than on commercial passenger flights, as illustrated by an illegal import of 390 kg of products, including bushmeat, at Zurich airport in December 2011.

The present study has provided information on the extent of illegal meat imports at two Swiss airports but clearly does not represent the

full picture for the whole country. Since the likelihood of pathogen introduction by illegal imports depends on the quantity of meat brought into Switzerland, illegal meat imports other than bushmeat are likely to pose a greater risk to the livestock population. Although it is recognised that the majority of emerging zoonotic diseases originate from wildlife (6), a variety of livestock pathogens may be introduced through the illegal trade in meat from domestic animals. Such diseases include foot and mouth disease, classical swine fever, African swine fever and Newcastle disease, as well as zoonoses such as bovine tuberculosis and brucellosis.

Data on methods used to process the intercepted meats were missing for the majority (87%) of the confiscated products. However, among the identified processing methods (18% of all meat imports) almost 30% was fresh meat, which offers good conditions for pathogen survival. The feeding of swill to pigs and other methods of disposal such as discarding litter could thus result in outbreaks of animal disease (2). However, in Switzerland, feeding swill to pigs has been prohibited since July 2011 (Swiss legislation on waste management of animal by-products, SR 916.441.22, art. 27), therefore introduction of contagious livestock diseases to farms by this route will be limited to the illegal feeding of food waste.

Several assumptions were made in the model used for estimating the total quantity of illegally imported meat and bushmeat into Switzerland. For each airport, national air travel statistics were available only on the total number of passengers passing through (i.e. both those arriving and those departing). It had to be assumed, therefore, that the total number of passengers arriving was 50% of the total number of passengers passing through. This assumption is consistent with data available from the annual reports of the two airports (30, 31).

Expert opinions estimated the proportion of passengers who declare their products to the customs department; these opinions were based on internal airport statistics, thus reducing the level of uncertainty. It was further assumed that passengers declaring particular products

(animal product or others) would declare everything else that should be declared. This might hold true for the majority of passengers, as they are aware about what can and cannot be legally imported into Switzerland. The proportion of passengers who did not initially declare the imports and whose luggage was searched by customs officers was estimated based on the expert opinion of two independent persons at the airports, which helped to reduce the high level of uncertainty of this parameter. This probability was validated by extrapolating the proportion of searched luggage on intervention days, taking into account the greater number of inspections on those days. The probability (P2) used in the model, based on expert opinion, was found to be 2.1 times higher in Zurich and 5.4 times higher in Geneva than the probabilities estimated on the intervention days. Possible explanations for this discrepancy may be that customs officials overestimated the proportion of searched luggage, that not all seizures were entered into the database, and that the success rate for detecting illegal meat imports was higher during the intervention exercise than during routine inspections. Because of the uncertainty regarding the proportion of searched luggage, the PERT distribution of this parameter in the model was defined with a relatively large variability of ± 50%. Nevertheless, this uncertainty probably did not have a major impact on the model outcome, because of the demonstrated low influence of this parameter in the sensitivity analysis. Another assumption was that whenever the luggage of a passenger was searched, all products of animal origin were recovered and confiscated by customs officials. This assumption was based on the high detection efficiency (85% to 100%) of the X-ray scanner machine (26), which was mainly used in Geneva but also in Zurich, and on the fact that when luggage was opened the search was done thoroughly.

Lastly, it was assumed that passengers whose luggage was searched had the same probability of importing illegal meat as the non-searched passengers. However, the experience of the customs officers means that they will search the luggage of a passenger whose profile fits that of a passenger with illegal imports, leading to a higher probability of detecting illegally imported products in searched than non-searched

luggage. Nevertheless, because the level of that difference is unknown, equal probability was assumed.

Conclusion

The statistical model used in the study enabled estimation of the total inflow of illegal meat imports coming into Switzerland each year on commercial passenger flights. The contribution of bushmeat to the total illegal meat imports was relatively small; however, the threat of disease outbreak in livestock or the human population in the importing country as a result of illegal bushmeat imports is real, especially given the broad range of animal species imported from different regions of the globe. A broader study is therefore recommended to estimate the health risks that could occur from meat illegally imported by all possible entry routes: namely air, road and ship transport. For better monitoring, the databases for meat imports at the airports should be standardised and include information on species and methods used to process the animal products. In addition, tools of genetic analysis would be helpful for rapid identification of species (32).

The risk of pathogen introduction into the EU and Switzerland through bushmeat is reduced by the fact that frequently the imported meat has been smoked. The smoking process was identified as the most common means of preservation (80%) of bushmeat imports brought into Paris (25). Harmonised surveillance at European ports of entry should be increased to reduce the importation of illegal meat. Information campaigns aimed at passengers are essential and should state clearly that the carriage of meat imports, including bushmeat, from non-EU countries is forbidden and that health risks could arise from such imports.

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Table I

Input variables and their sources in the model estimating the total quantity of meat and bushmeat illegally imported into Switzerland on commercial passenger flights

Name	Description	Value	Source
Npass	Annual number of passengers entering Switzerland via GE and ZH	PERT[a] (14.6, 16.6, 17.4) (× 1,000,000)	Min., median and max. of the annual total number of passengers managed by GE and ZH 2006–2010 divided by two (30, 31)
P1	Probability that the passenger will not declare anything	1- PERT (0.0033, 0.0039, 0.0049)	Expert opinion[b] Total number of passengers declaring something (mode: ZH: 0.33%, GE: 0.5%, min.– max.: mode ±10%) divided by the total number of incoming passengers
P2	Probability that the passenger's luggage will not be searched at the Swiss custom borders	1- PERT (0.0025, 0.0041, 0.0060)	Expert opinion[b] Mean of values from ZH and GE ZH: the luggage of 0.5% of all passengers taking the green exit will be searched (mode), min. – max.: mode ± 50% GE: 0.25% to 0.44% (mode: 0.32%) of luggage is searched
P3	Probability that the passenger whose luggage is searched is importing an animal product	PERT (0.023, 0.037, 0.077)	Annual number of confiscated animal products from the databases of ZH and GE (mode: monthly mean*12, min. – max.: mode ±10%) divided by the total number of searched luggage
P4	Probability that the imported animal product is meat	PERT (0.54, 0.68, 0.72)	Min., median and max. of the annual proportion of confiscated meat products among all confiscated animal products at ZH and GE (based on the database)
P5	Probability that the imported meat is bushmeat	PERT(0.0035, 0.005, 0.006)	Rounded min., median and max. of the annual proportion of confiscated bushmeat products among all confiscated meat products at ZH and GE

a) PERT distribution (min. – mode – max.)
b) Estimates provided by Head Customs Officers
GE: Geneva airport
ZH: Zurich airport

Table II
Annual number and total weight of confiscated meat products (excluding bushmeat) imported into Switzerland on commercial passenger flights from different geographical regions and the weight per confiscated import

Region of origin	Rounded annual number of confiscations	Weight of confiscated imported meat products (kg)		
		Rounded total per year	Median weight per import	Min. – max. weight per import
Asia	168	400	1.7	0.1–17
Middle East	222	660	2.3	0.1–39.6
North Africa	53	226	2.9	0.3–42.8
East Africa	21	79	2.4	0.1–21
Central/West Africa	52	245	3.4	0.2–42.1
Southern Africa	42	69	1.0	0.1–22
Eastern Europe	803	2,637	2.6	0.2–38.5
North America	53	184	1.4	0.1–34.6
Central/South America & Caribbean	368	1,057	2.1	0.1–30
Oceania	7	19	2.0	0.1–16
Unknown	7	46	4.5	0.7–30

Table III

Number and weight of confiscated bushmeat items* per country of origin imported into Switzerland on commercial passenger flights between May 2008 and October 2011 and the weight per confiscated import based on customs records

Country of origin	Species of origin (number of confiscations)	Weight (kg) of confiscated illegally imported bushmeat		
		Total weight of all imports	Median weight per import	Min. – max. weight per import
Cameroon	Antelope (1)	141.4	6.9	1.5 – 44
	Pangolin (1)			
	Bird (1)			
	Porcupine (2)			
	Other rodents (2)			
	Game animal (2)			
	Not specified (3)			
Côte d'Ivoire	Ape (1)	15.9	4.5	4 – 7.4
	Porcupine (1)			
	Not specified (1)			
Benin	Other rodents (1)	15.5	7.75	4.5 – 11
	Not specified (1)			
Ghana	Not specified (2)	32	16	2 – 30
South Africa	Antelope (1)	4.6	0.4	0.3 – 3.9
	Game animal (1)			
	Not specified (1)			
China	Not specified (3)	20.5	4.9	2 – 13.6
Thailand	Other rodents (1)	2.9	1.45	0.5 – 2.4
	Not specified (1)			
Ecuador	Game animal (1)	4.7	4.7	4.7
Chile	Other rodents (1)	1.1	1.1	1.1
Colombia	Antelope (1)**	10.4	10.4	10.4

* total number of bushmeat imports = 30

** see discussion

Table IV
Estimation of the total annual weight of meat products and bushmeat illegally imported into Switzerland on commercial passenger flights

Region of origin	Estimated annual weight (tonnes) of illegally imported meat, exclusive of bushmeat			Estimated annual weight (tonnes) of illegally imported bushmeat		
	2.5 percentile	Median	97.5 percentile	2.5 percentile	Median	97.5 percentile
Asia	15.5	94.2	510.9	0.07	1.4	14.8
Middle East	20.6	125.4	680.0	0	0	0
North Africa	5.1	31.4	171.4	0	0	0
East Africa	2.0	11.9	65.8	0	0	1.7
Central/West Africa	4.9	30.0	164.6	0.4	5.6	51.2
Southern Africa	3.8	23.5	128.4	0	0.8	9.5
Eastern Europe	73.5	449.2	2,430.9	0	0	0
North America	5.6	34.6	186.7	0	0	0
Central/South America & Caribbean	33.9	207.0	1,122.9	0	0.8	9.7
Oceania	0.6	3.6	20.7	0	0	0
Total	165.8	1,012.8	5,494.3	0.5	8.6	88.5

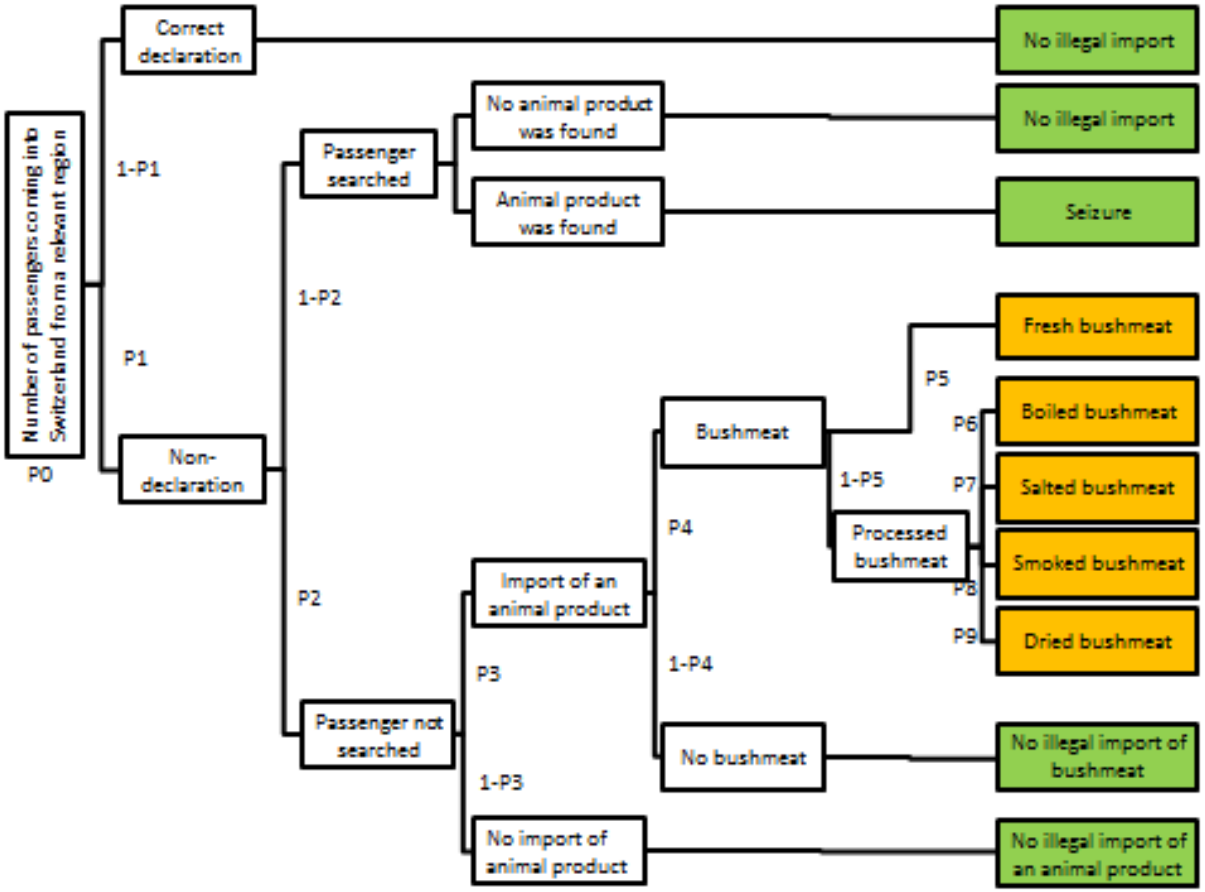


Fig. 1
Scenario tree for the import of illegal meat and bushmeat into Switzerland on commercial passenger flights
Modified from Laubli, 2010 (27)

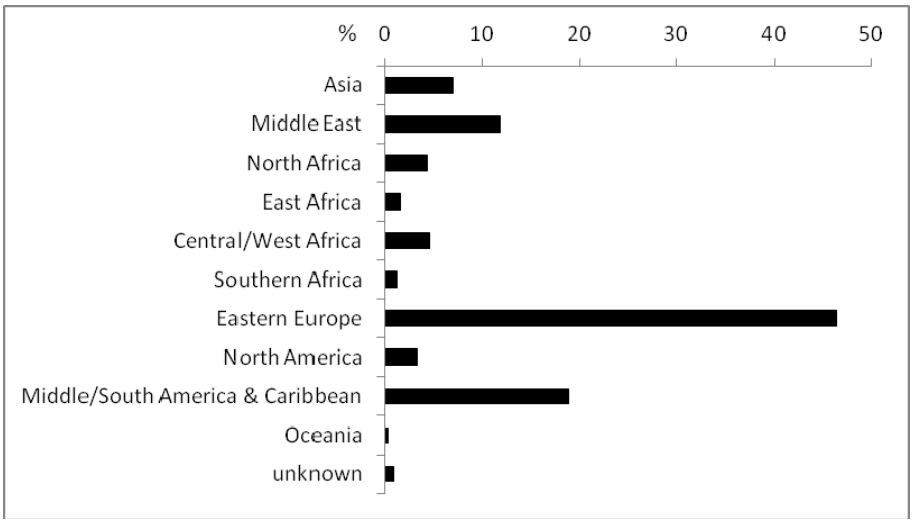
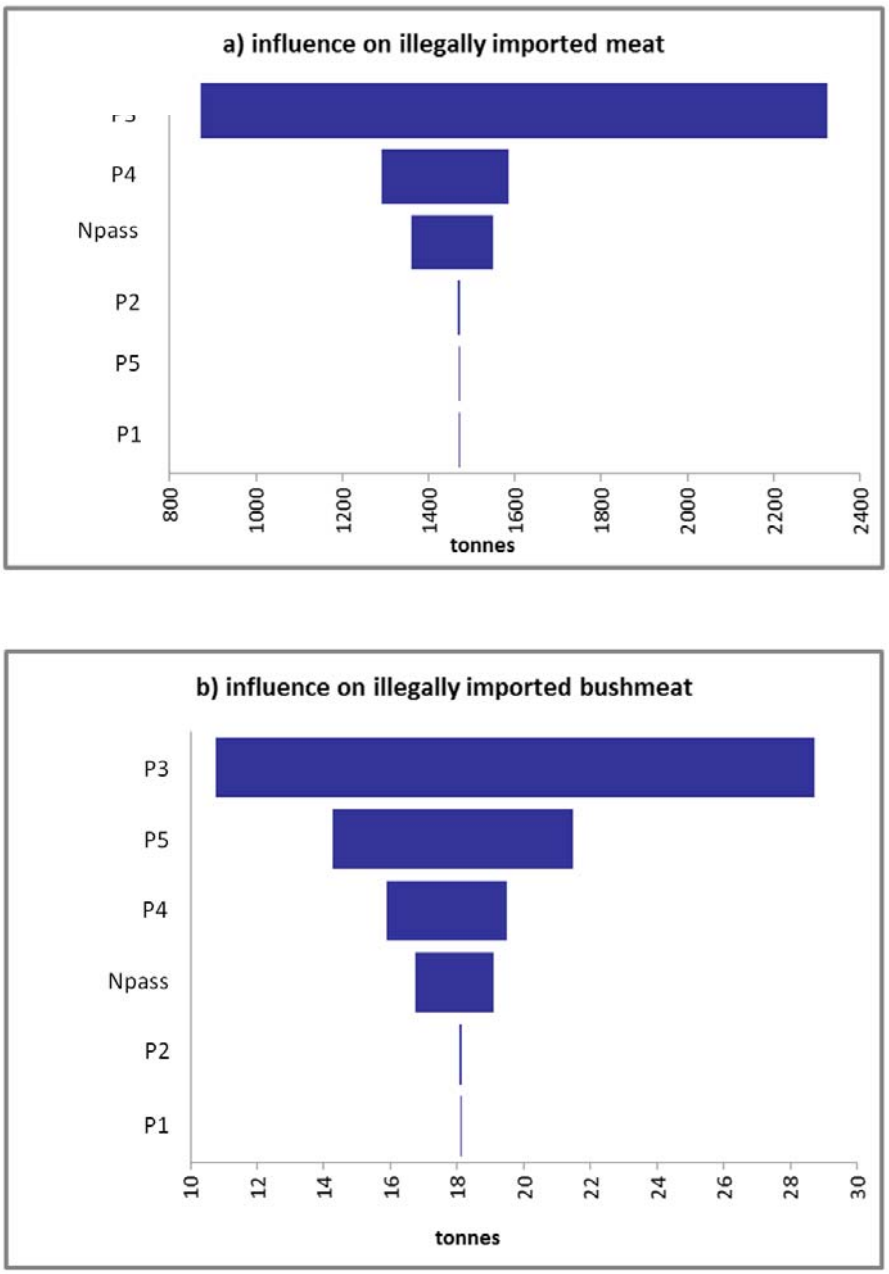


Fig. 2

Percentage contribution of different geographical regions to the quantity of meat (including bushmeat) illegally imported into Switzerland on passenger flights, based on the weight (kg) of confiscated meat products



Npass: annual number of passengers entering Switzerland through Zurich and Geneva airports
P1: probability that the passenger will not declare anything
P2: probability that the passenger's luggage will not be searched at the Swiss custom borders
P3: probability that the passenger whose luggage is searched is importing an animal product
P4: probability that the imported animal product is meat
P5: probability that the imported meat is bushmeat

Fig. 3

Tornado graph of the sensitivity analysis on the estimated annual quantity of illegally imported meat (a) and bushmeat (b) in consideration of the input parameters of the model