

Incidence of rabies and post-exposure treatment in developing countries

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The results are reported of a ranking analysis of epidemiological data of reservoirs of canine rabies in 30 countries. For those countries where combined antibody and vaccine are not routinely administered and the control of canine rabies is inadequate, "standard conditions" of 2000 human post-exposure treatments per million population per annum and 3 cases of human rabies per million population were derived. These parameters can be used to predict the cost-effectiveness of various strategies of rabies prevention and control.

Rabies is a major public health hazard in many developing countries, where the dog population forms the reservoir of the disease. According to the FAO/WHO/OIE Animal Health Yearbook (1), 87 countries and territories are still infected by rabies, these areas accounting for more than 99% of all reported human deaths from rabies in the world.

Most countries have now reached a stage of development that permits them to improve services for disease surveillance and human post-exposure treatment. However, so far, for rabies no model conditions have been identified for forecasting service needs and cost estimates, e.g., manpower, materials, etc. The reliability of epidemiological data from areas where canine rabies is endemic is frequently low, since the incidence of the disease is particularly high where the health infrastructure and data reporting facilities are poor. For 30 countries, we have obtained, from as many sources as possible, information on the number of persons treated for or who died from rabies, and have used this to derive guiding values for forecasting rabies vaccine and service needs.

MATERIALS AND METHODS

Data on human deaths from rabies and on human post-exposure treatment were obtained for the 30 countries and territories shown in Table 1. Nevertheless, the exact association between human populations and reported data could not always be determined; for example, the information sometimes

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related to the whole country but on other occasions was limited to a capital city or state. A centre for post-exposure treatment in a given area may show a disproportionately high rate of treatments because many patients from outside that area are also treated there. We therefore collected as many reports as possible from a wide range of countries and selected for further analysis those data that related to the same time period. The rates obtained were subjected to a ranking analysis. Data for small populations or from limited geographical areas (less than 10 000 km²) were rejected. Also, large discrepancies in data reported from the same country or from areas where similar economic and epidemiological situations prevailed were treated with caution. Because of improvements made in reporting procedures in many countries during the 1970s, only data from 1979 were used in the study. Human population figures were estimated (2) if not supplied by the countries themselves.

RESULTS

Incidence of rabies post-exposure treatment

Table 2 shows the rates of rabies post-exposure treatment (per million population) for those countries used in the study. The wide range of values probably reflects the lack of adequate vaccine provision or reporting as well as the confinement of rabies to small areas of countries. These factors tend to produce relatively low rates. The maximum rate of post-exposure treatment was 4750 per million, while the mean rate for the 30 countries covered was 866.8 per million (Table 2). For the 10 countries with post-exposure treatment rates greater than 1000, the mean

Table 1. Number of cases of human rabies and number of human post-exposure treatments

Country or territory (with references)	Population (millions)	No. of post-exposure treatments	No. of cases of human rabies
Algeria ^a	20.96	40 000	50
Argentina (4)	27.056	54 028	6
Bolivia ^b	5.5	2575	6
Brazil ^{b, c}	120.0	147 620	148
Colombia (5)	26.9	13 225	25
Ecuador ^{b, c}	8.0	2540	25
El Salvador ^b	4.8	22 802	11
Ethiopia ^{b, d}	32.6	2400	412
Ghana ^b	11.6	31	21
Honduras ^b	3.6	3822	12
India (6, 7)	693.9	3 000 000	20 000
Bareilly (city in India) (7)	0.431	1053	11
Indonesia (8)	151.9	20 709	67
Lao People's Democratic Republic ^b	3.3	50	1
Mali ^b	6.6	2496	5
Morocco ^e	20.0	17 000	50
Nepal ^f	15.8	6968	59
Paraguay ^b	3.0	1649	4
Peru ^{b, c}	17.7	13 116	17
South Africa ^b	25.5	106	2
Sri Lanka (9)	14.9	8000	153
Sudan ^e	22.0	25 000	25
Syrian Arab Republic ^e	9.0	50	2
Thailand (10)	49.0	63 939	370
Tunisia ^a	6.996	18 600	20
Turkey ^e	45.0	62 500	35
Venezuela ^{b, c}	13.2	7112	11
Viet Nam ^b	52.3	33 225	89
Yemen Arab Republic ^e	6.4	150	23
Zimbabwe ^b	7.2	837	16

^a WHO consultation on rabies control in the Maghreb. Unpublished document, WHO/VPH, 1985.

^b World survey of rabies, XIX. Unpublished document (WHO/RABIES/82.192).

^c Fernandes, M. V., personal communication.

^d Preliminary programme of rabies prevention and control in Socialist Ethiopia. Addis Ababa, Ministry of Health, National Project Document, 1983.

^e WHO Mediterranean Zoonoses Control Programme: report of a seminar on planning and management of national programmes of canine rabies control. Unpublished document.

^f Human and Canine Rabies Control Project. Kathmandu, His Majesty's Government of Nepal, Ministry of Health, 1983.

rate was 1988 per million. It can be assumed that this level represents a plateau value above which post-exposure treatment is no longer effective, unless special conditions, such as lack of laboratory diagnosis and surveillance in animals, are responsible for a higher (indiscriminate) intensity of treatment.

Incidence of human rabies

The incidence rates of human rabies in the countries studied are shown in Table 3. The rates vary

considerably from 0.1 in South Africa to 28.8 cases per million in India. It is interesting to note that in the city of Bareilly (Uttar Pradesh) the rate (25.5 per million) is similar to that in India as a whole, while the next-highest rates were in Ethiopia (12.6) and Sri Lanka (10.3), two countries where the geographical and epidemiological situations are similar. Also, Thailand, which has the fourth highest rate (7.6), is in south-east Asia.

Low incidence rates of human rabies in countries

Table 2. Number of human post-exposure treatments for rabies per million population in the 30 countries studied

Country or territory	No. of treatments (per million)
Ghana	2.7
South Africa	4.2
Syrian Arab Republic	5.6
Lao People's Democratic Republic	15.2
Botswana	20.0
Yemen Arab Republic	23.4
Ethiopia	73.6
Zimbabwe	116.3
Indonesia	136.3
Ecuador	317.5
Mali	378.2
Nepal	441.0
Bolivia	468.2
Colombia	491.6
Sri Lanka	536.9
Venezuela	538.8
Paraguay	549.7
Viet Nam	635.3
Peru	741.0
Morocco	809.5
Honduras	1061.7
Sudan	1136.4
Brazil	1230.2
Turkey	1388.9
Thailand	1304.9
Algeria	1908.4
Argentina	1996.9
Bareilly (city in India)	2443.2
Tunisia	2658.7
El Salvador	4570.4
Average	866.8

Table 3. Number of cases of human rabies per million population in the countries studied

Country or territory	No. of cases (per million)
South Africa	0.1
Argentina	0.2
Syrian Arab Republic	0.2
Lao People's Democratic Republic	0.3
Indonesia	0.4
Mali	0.8
Turkey	0.8
Venezuela	0.8
Colombia	0.9
Peru	1.0
Bolivia	1.1
Sudan	1.1
Brazil	1.2
Paraguay	1.3
Viet Nam	1.7
Ghana	1.8
Zimbabwe	2.2
El Salvador	2.3
Algeria	2.4
Morocco	2.4
Tunisia	2.9
Ecuador	3.1
Honduras	3.3
Yemen Arab Republic	3.6
Nepal	3.7
Botswana	6.3
Thailand	7.6
Sri Lanka	10.3
Ethiopia	12.6
Bareilly (city in India)	25.5
India	28.8
Average	3.7

probably arise because of the following circumstances:

- absence of rabies in a large part of the country (with or without continuous treatment of patients after dog bites);
- reduced risk of rabies due to dog vaccination programmes (with continuous post-exposure treatment);
- inadequate diagnosis and reporting of human rabies in large areas of the country.

It is difficult to analyse retrospectively the reasons

for low human incidence rates, unless reliable surveillance data on dog rabies indicate a low level of infection in the animal reservoir, as is the case in Argentina, for example. The reported human incidence rate tends, in general, to be 2–3 per million if no control measures are taken in the dog population and both diagnosis of human cases and reporting are deficient. In contrast, countries with good facilities for diagnosing human rabies have, in the absence of country-wide dog immunization, 3–8 human cases per million population. For some Asian countries, however, the rate may be considerably higher.

Relationship between post-exposure treatment and number of cases of human rabies

In order to develop a model of the standard epidemiological situation for rabies in humans, emphasis should be placed on data from areas with high rates of post-exposure treatment. We therefore selected for further analysis data from the 10 countries reporting rates greater than 1000 per million population (Table 4). In these areas, the incidence of rabies in dogs is probably not markedly reduced by control measures.

Data for Argentina can be excluded from the analysis, since it is largely rabies-free, and also for Bareilly, where the rate is extremely high and may be typical only of conditions in south-east Asia. The remaining eight countries show a mean level of 2.7 human deaths from rabies per million population. In view of the high rate of human deaths from rabies in countries such as Thailand and Honduras (Table 4), on a global scale an annual rate of at least 3 human deaths per million is probable, even in countries with

2000 post-exposure treatments per million. This "rule" may vary, however, depending on the country, its population density, and efforts to control rabies among its dog population. In this respect, the dog-man relationship may also play a role. For some countries in south-east Asia, considerably higher mortality rates may apply.

DISCUSSION

Population-related data for human post-exposure treatment and number of rabies cases are available at an acceptable level of reliability for countries where the surveillance and medical care system function relatively well. Analysis of the data described here indicates that the minimum acceptable level of post-exposure treatment is 2000 persons per million inhabitants in areas infected with canine rabies. Moreover, even this level of treatment will unavoidably result in at least 3 human deaths from rabies per million population per annum. This model applies to those areas where post-exposure treatment consists only of vaccination; the number of deaths could be drastically reduced, however, by combined passive and active immunization programmes (3).

Using the epidemiological model discussed here, we can estimate the cost-effectiveness of various strategies for the control of rabies. One possibility would be to concentrate on human post-exposure vaccination either with or without general passive immunization. Alternatively, efforts could be directed at eliminating the disease from its canine reservoir; nevertheless, the cost-effectiveness of this strategy would require careful analysis of the numbers of dogs to be vaccinated per million inhabitants as well as of the cost of vaccine and its delivery.^a

The validity of the model described here for human rabies post-exposure treatment in areas where canine rabies is endemic should be carefully checked by national authorities. For this purpose, field data from comprehensive national programmes for the control of human and canine rabies need to be compared carefully with the forecasts.

^a MESLIN, F. Cost-effectiveness of alternative strategies for human and canine rabies control (unpublished results).

Table 4. Incidence of rabies in countries with high rates of human post-exposure treatment

Country or territory	No. of treatments (per million population)	No. of human deaths from rabies (per million population)
Honduras	1061.7	3.3
Thailand	1304.9	7.6
Sudan	1136.4	1.1
Brazil	1230.2	1.2
Turkey	1388.9	0.8
Algeria	1908.4	2.4
Argentina ^a	1996.9	0.2
Bareilly (city in India)	2443.2	25.5
India	2658.7	28.8
El Salvador	4750.4	2.3
Average	1988.0	4.7
Average (excluding Argentina and Bareilly)	1930.0	2.7

^a Argentina is almost rabies-free.

RÉSUMÉ

L'INCIDENCE DE LA RAGE ET DU TRAITEMENT APRÈS EXPOSITION
DANS LES PAYS EN VOIE DE DÉVELOPPEMENT

Les données épidémiologiques provenant de 30 pays et territoires où la rage canine est présente sont examinées dans

le but de définir une situation type en ce qui concerne la fréquence du traitement après exposition et celle des cas de

rage chez l'homme.

Les pays ont été classés en fonction des taux obtenus. Pour les 10 pays signalant des taux de traitement après exposition supérieurs à 1000 par million d'habitants, le taux moyen est de 1988, ce qui peut représenter un seuil au-dessus duquel des services de traitement après exposition ne sont plus très efficaces. Les données indiquent qu'en dépit de l'administration d'environ 2000 traitements, la rage provoque 3 décès par million d'habitants chaque année.

Il est possible de présumer que cette "situation type" (à savoir 2000 traitements et 3 décès/million d'habitants) existe dans les régions où seul le vaccin est administré comme traitement après exposition et où la lutte contre la rage canine laisse à désirer. Les connaissances actuelles permettent d'affirmer qu'il est possible de réduire considérablement ce taux de mortalité en combinant l'immunisation passive et la vaccination.

Compte tenu de cette situation type, il est possible d'estimer le rapport coût/efficacité de diverses stratégies de lutte contre la rage, pas exemple celle qui privilégierait la vaccination humaine après exposition, associée ou non à l'immunisation passive, ou celle qui viserait l'élimination de la maladie dans le réservoir canin. L'évaluation du rapport coût/efficacité de cette dernière stratégie demande, toutefois, une analyse poussée du nombre de chiens vaccinés par million d'habitants et du coût du vaccin et de son administration. Il en sera question dans un document qui paraîtra ultérieurement.

La validité de la situation type susmentionnée doit être vérifiée par les autorités nationales qui souhaitent se servir de ce modèle. A cette fin, elles devront comparer soigneusement les prévisions théoriques et les données réelles provenant de programmes nationaux complets de lutte contre la rage humaine et canine.

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