

# Sustainability of pyrethroid-impregnated bednets for malaria control in Afghan communities\*

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*Between 1992 and 1995 a series of studies was undertaken to assess the long-term suitability of pyrethroid-impregnated bednets (PIBs) for malaria control in Afghan refugee communities in two villages in North-West Frontier Province, Pakistan. During 1992, 86% of bednet owners volunteered to have their bednets re-impregnated, and a further 15% of families purchased nets at two-thirds of cost price. From 1992 onwards, 27% of the villagers returned to Afghanistan, and annual house spraying campaigns were introduced to protect those still resident but sleeping without bednets. Within 3 years, these campaigns, together with PIBs, reduced the annual incidence of malaria by 87%, from 597 to 78 cases per 1000 population. Nevertheless, 65% of resident families continued to re-impregnate their nets annually with permethrin. To assess whether PIBs were still being used and were still protective, in view of these reduced transmission rates, we carried out a case-control study in 1994 on febrile or otherwise symptomatic patients presenting at village health centres. Comparison of the slide-positivity rates of PIB users and those without bednets showed that regular usage reduced the odds of contracting falciparum and vivax malaria to 0.22 (95% confidence interval (CI): 0.09–0.55) and 0.31 (95% CI: 0.19–0.51), respectively. There was no evidence of a sex- or age-bias in bednet use or in protective effect. The results indicate that a community-based PIB programme is an appropriate malaria control measure in areas where management or security problems make traditional house-spraying campaigns impossible.*

*A relevant finding for those involved in the monitoring of bednet distribution projects is that the local coverage of bednets and the local impact on malaria, even when introduced to remote areas, can be estimated very cheaply by health centre microscopists who simply catalogue blood film diagnoses according to patients' bednet use practices.*

## Introduction

Field trials in many countries have demonstrated that use of pyrethroid-impregnated bednets (PIBs) is effective for preventing malaria (1). Even in countries where there is no great tradition of bednet use, carefully conducted field trials, where appropriate attention is paid to health education before and during implementation, generally show that recipients use the nets with enthusiasm and to good effect. One such trial was conducted in Afghan refugee camps in 1991; the incidence of clinical parasitaemic episodes was reduced by 53% in an intervention group whose previous use of nets was only 2% (2). Nevertheless, a number of questions remain on whether use of PIBs

is a sustainable strategy for malaria control: Will recipients continue to use their nets in the long term in the absence of further encouragement? Will recipients actively participate in the re-impregnation process and thereby help to reduce recurrent implementation costs? Will neighbours buy bednets for themselves? Will the reduction in malaria be sustained? Will people continue to use nets if a second method of control — house spraying, for example — is conducted simultaneously?

This article describes a number of follow-up studies in the Afghan trial villages that attempt to answer such questions.

## Methods

### *Distribution, re-impregnation and sale of bednets*

The two trial villages, Baghicha and Kagan, are situated in Mardan district, North-West Frontier Province, Pakistan. Extended family groups of Afghan refugees live in houses constructed from mud and located within high-walled compounds. The underlying water table is higher than normal for the district,

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and both villages are malarious. Refugees sleep outdoors during the summer and indoors from October. The populations in a 1991 census were 11 220 (Baghicha) and 2735 (Kagan). In the PIB trial conducted in 1991, 20% of the village health centres' family registration cards were selected at random and divided into two groups. One group (173 families) was issued with imported, 100-denier, polyester bednets, while the other group (186 families) served as controls. The two groups were similar with respect to variables that might otherwise confound the results of the trial (2). The bednets were designed to fit around the wooden-framed rope beds (*charpois*) used by Afghans and were dipped in an aqueous solution of permethrin (25% emulsifiable concentrate; Imperator, ICI, Karachi, Pakistan) to achieve an application rate of  $0.5 \text{ g} \cdot \text{m}^{-2}$ . A pre-trial census ensured that each family received sufficient nets to cover all members. In December 1991, at the end of the trial, bednets were also distributed to the 186 families belonging to the control group. Families were then told they could do what they liked with the nets but that if they kept them, the nets would be re-impregnated the following year.

In April 1992 a free net re-impregnation service was set up, run by basic health workers at the two village health centres. Family-size bednets were sold for Rs 100 per net (US\$ 3.25 at 1992 rates), two-thirds of the purchase price. The availability of these services was broadcast by loudspeaker from village mosques. To ensure accuracy in record keeping, we provided re-treatment services only to families who produced their health centre record card and number. Those families who had been issued with nets in 1991 but failed to appear with their nets in 1992 were visited at home. In 1993 and 1994 the re-impregnation service was provided but no further nets were put on sale.

### **Protection from malaria among PIB users**

Each health centre employed a malaria supervisor to take blood smears and administer antimalarials and a microscopist to examine the slides. All out-patients suspected of having malaria were registered by name and family code number and given presumptive treatment with chloroquine while awaiting the microscopy results. Those patients who were confirmed positive were treated with chloroquine (25 mg per kg body weight), and cases of vivax malaria were given an additional 5-day course of primaquine (1.25 mg per kg body weight). Health centre microscopists were monitored monthly, ensuring that incorrect diagnoses were below 3%.

To determine the protective effect of PIBs, records of all patients from whom blood smears had

been taken between June and December 1994 were extracted from the registers and matched with the code numbers of families known to possess bednets. Since not all the bednet owners necessarily used their nets regularly, the malaria supervisors were instructed to ask in passing during smear-taking whether or not the patient used a bednet. Because the malaria supervisors were not employed by HealthNet International, it was hoped that their enquiries would elicit a more truthful response from patients.

A parasite prevalence survey was also conducted in October 1994, the month of peak malaria transmission. For this purpose, 196 families known to possess bednets were randomly selected from those who had participated in the trial in 1991. Also 230 families known not to possess nets were randomly selected from the health centres' records. Thick and thin smears were taken from each family member, stained with Giemsa, and examined "blind" by an experienced microscopist.

### **Analysis of the data**

For the analysis of the passive case detection data, patients presenting at the health centres with symptoms of malaria and who were slide positive were taken to be cases, distinguishing between falciparum and vivax malaria. Patients with symptoms of malaria but with a negative slide and who presented during the same period at the same health centres were taken as controls. By comparing cases with controls, we calculated odds ratios for protection by bednets.

Data were analysed using Epi Info software (3). Discrete variables were compared using  $\chi^2$  tests, while odds ratios were calculated using Mantel-Haenszel stratified cross-tabulations and summary  $\chi^2$  tests.

### **Village incidences**

Malaria cases from health centre records were compiled to produce annual incidence and slide positivity rates for 1991 to 1994.

## **Results**

### **Distribution, re-impregnation and sale of bednets**

The data on distribution, re-treatment and sale of bednets are summarized in Table 1. The average number of nets issued in 1991 was sufficient for a family of 8.6 persons (average family size 7.8). The

Table 1: Ownership of bednets in the trial villages and attendance at the insecticide re-treatment sessions

	Intervention families	Control families	Families sold nets	Other families
Original number of families	173; 10 <sup>a</sup>	186; 10 <sup>a</sup>	271; 15 <sup>a</sup>	—
No. of nets issued or purchased	699	596	615	—
<i>Mean no. of nets per family</i>				
Double size	2.3	2.8	2.3	—
Single size	1.8	0.4	—	—
No. of families re-treating nets in 1992	150 (87) <sup>b</sup>	157 (84)	—	—
No. of nets re-treated in 1992	605; 4.0 <sup>c</sup>	497; 3.2	—	—
No. of families still present in 1994	125	141	201	—
No. of families re-treating nets in 1994	80 (64)	94 (67)	123 (61)	83
No. of nets re-treated in 1994	313; 3.9	270; 2.9	301; 2.4	173; 2.1

<sup>a</sup> Original families expressed as % of village.

<sup>b</sup> Figures in parentheses are percentages.

<sup>c</sup> Figures in italics are the mean number of nets per family.

intervention families were issued with a mixture of single- and double-size nets, but owing to a lack of the single-size nets, the control families received mainly double-size nets. In 1992, a year after the PIB trial, a further 271 (15%) refugee families bought 615 double-size nets. Of these families, 40% purchased only one net each, and thus did not meet the entire needs of an average-size family (on average, families purchased 2.3 nets).

In 1992 a total of 86% of the trial families responded to the mosques' broadcasts and came to the health centres to have their bednets re-treated; the remaining 14% of trial families were later visited in their homes whereupon their nets were re-treated *in situ*. Between the summers of 1992 and 1994, a total of 27% of families from Baghicha and Kagan returned to Afghanistan. Of the trial families still resident in 1994, the proportion responding to the broadcasts had fallen to 65%. The reduction in the rate of net re-treatment among families who had originally purchased nets was approximately the same as that among trial families who had originally been given bednets.

Between 1992 and 1994, a further 83 village families acquired bednets and attended re-treatment sessions (this group accounted for 22% of all the families who had nets re-treated in 1994). For the group of 297 families who received or purchased bednets directly from HealthNet International and were still turning up annually to the re-treatment sessions, 92% of the nets originally issued could still be accounted for in 1994. Thus families who had acquired nets from sources other than HealthNet International had mostly obtained them from those families who were no longer responding to the mosques' broadcasts or from those who had returned to Afghanistan, since there were no other sources of polyester nets in the study area.

### Protection from malaria among PIB users

The redistribution of bednets within the study community between 1992 and 1994 meant that each remaining family could be placed into one of the following categories: a) trial families from 1991 re-treating their nets in 1994 (174 families); b) trial families from 1991 not re-treating their nets in 1994 (92 families); c) non-trial families who had acquired nets after 1991, re-treating them in 1994 (206); d) non-trial families who had acquired nets after 1991 but did not re-treat them in 1994 (ca. 78 families); e) families who had not acquired nets (ca. 785 families). Table 2 shows the results of an analysis, with respect to these categories, of passive case detection (PCD) records from the Kagan and Baghicha health centres (these records were of patients showing clinical symptoms indicative of malaria, with the diagnosis verified positive or negative by microscopy). For families possessing nets (categories a–d)), the *Plasmodium falciparum* positivity rate among symptomatic outpatients at, for example, the Kagan health centre, was 0.7% (13/1826), whereas for families without nets (category e)) the rate was 1.2% (28/2247). Comparison of these data with those from the Baghicha clinic (which exhibited the same trend), showed that the overall odds of contracting falciparum malaria for families with bednets was 0.50 relative to those without nets (data stratified by village and age group). Not all the families with nets had sufficient for every member, nor did all families re-treat their nets in 1994; 0.50 is therefore an underestimate of the true protective value of PIBs to users. A more realistic estimate is obtained if the families from the 1991 trial known to have re-treated their nets (category a) above) are compared with families who lacked nets: the *P. falciparum* rate among category a) families from Kagan, for example, was only

Table 2: Distribution of malaria cases among Afghan refugee users or owners of permethrin-impregnated bednets and among those who did not use or own bednets, by passive case detection (PCD) at village health centres or from parasite prevalence surveys

	No. in Baghicha		No. in Kagan		Odds ratio	$\chi^2$ test	P-value
	+ve	-ve	+ve	-ve			
<i>PCD at clinics:<sup>a</sup></i>							
<i>P. falciparum</i>	12 (0.4) <sup>b</sup>	33 (1.0)	13 (0.7)	28 (1.2)	0.50; 0.31, 0.79 <sup>c</sup>	8.3	0.004
<i>P. vivax</i>	60 (2.1)	91 (2.8)	30 (1.6)	69 (3.1)	0.65; 0.50, 0.85	9.6	0.002
No. slides examined	2777	3272	1826	2247			
<i>PCD at clinics:<sup>d</sup></i>							
<i>P. falciparum</i>	3 (0.4)	33 (1.0)	5 (0.5)	28 (1.2)	0.39; 0.18, 0.79	6.5	0.011
<i>P. vivax</i>	14 (1.7)	91 (2.8)	12 (1.2)	69 (3.1)	0.48; 0.32, 0.73	11.9	0.001
No. slides examined	826	3272	1004	2247			
<i>PCD at clinics:<sup>e</sup></i>							
<i>P. falciparum</i>	1 (0.2)	44 (0.8)	4 (0.3)	37 (1.4)	0.22; 0.09, 0.55	11.8	0.001
<i>P. vivax</i>	2 (0.4)	149 (2.7)	16 (1.1)	80 (3.0)	0.31; 0.19, 0.51	21.5	0.001
No. slides examined	488	5561	1337	2643			
<i>Parasite prevalence surveys:<sup>f</sup></i>							
<i>P. falciparum</i>	0 (0)	1 (0.01)	4 (0.01)	8 (0.02)	0.47; 0.15, 1.55	0.97	0.326
<i>P. vivax</i>	6 (0.06)	8 (0.06)	7 (0.02)	14 (0.04)	0.68; 0.34, 1.38	0.89	0.345
No. slides examined	1081	1394	312	338			

<sup>a</sup> +ve, individuals from families who possessed bednets; -ve, individuals from families who did not possess bednets.

<sup>b</sup> Figures in parentheses are %.

<sup>c</sup> Figures in italics are 95% confidence intervals.

<sup>d</sup> +ve, individuals from families who took part in the 1991 trial and who had their nets re-treated in 1994; -ve, individuals from families who did not possess nets.

<sup>e</sup> +ve, individuals claiming to use bednets; -ve, individuals not claiming to use bednets.

<sup>f</sup> +ve, individuals from bednet-owning families; -ve, individuals from families not owning bednets.

0.5% (5/1004) and the overall odds ratio for both villages was reduced to 0.39.

The parasite positivity rate for trial families who re-treated their nets (2.1%, 31/1447) was not significantly different from that for families who failed to do so (1.9%, 20/1035) ( $\chi^2$  test = 0.08,  $P = 0.77$ ). This result is potentially important for determining the required re-treatment frequency.

Not all members of families who re-treated their nets (category a) necessarily used them regularly. To obtain an estimate of the odds ratio for regular users, we compared the parasite positivity rates for individuals who claimed to use nets against those who did not admit to using them. This gave a *P. falciparum* positivity rate of only 0.3% (4/1337) for bednet users from Kagan and, together with the results from Baghicha, an odds ratio for contracting falciparum malaria of 0.22.

PIBs also reduced the chances of becoming infected with vivax malaria, although to a lesser extent than for falciparum malaria (Table 2).

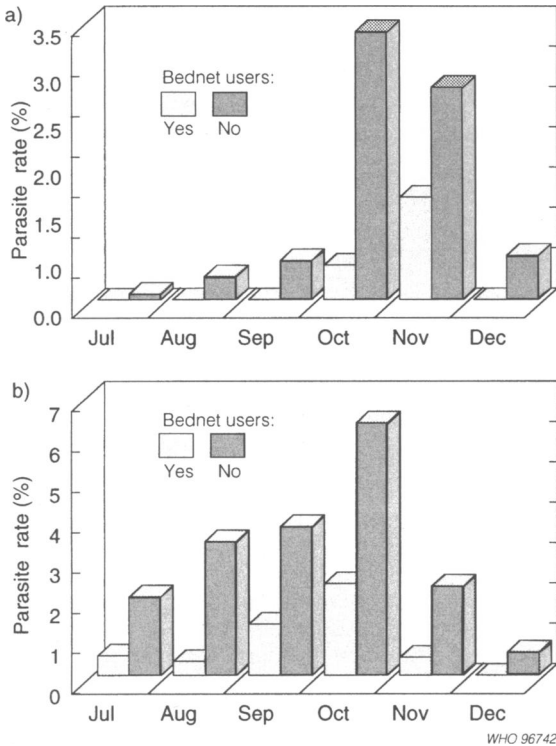
Fig. 1 shows the PCD slide positivity rates among bednet users and non-users per month. The seasonal patterns are clear, with the peak for *P. falciparum* malaria occurring slightly later than that for *P. vivax* malaria. As the year progressed and

grew colder, the *P. falciparum* positivity rates tended to converge for PIB users and non-users, suggesting that some owners no longer used their nets regularly after they moved indoors. For *P. vivax*, however, this convergence was not observed.

Parasite rates in the two villages were very low during the second half of 1994 because of house spraying campaigns carried out during July. Parasite prevalence surveys in October yielded very few positive cases (1.5%, 48/3215) (Table 2). Although the odds ratios were not statistically significant for families that used bednets relative to those that did not, the values (*P. falciparum* (0.47); *P. vivax* (0.68)) and trends were similar to those obtained by PCD at the health centres.

Census data revealed that 49.3% of the study population was male, whereas 58% of those who attended malaria clinics were female. The proportion of females who claimed to use bednets (15.4%, 1042/6761) was similar to that of males (17.4%, 846/4870). A bias towards use by males might be expected in families who bought only one or two nets, since not all females would necessarily be granted access to them in the male-dominant Afghan society. However, the proportions of males and females who claimed to use the nets were very similar;

Fig. 1. Monthly malaria slide-positivity rates among users of permethrin-impregnated bednets and non-users presenting at the village health centres. a) *Plasmodium falciparum*; b) *P. vivax*.



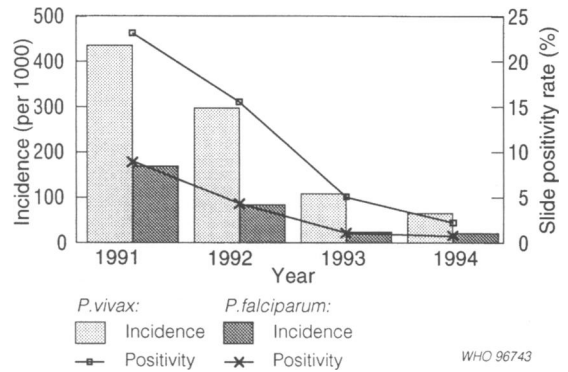
for example, among the Kagan families who had purchased nets, 65.1% (69/106) of females and 67.5% (54/80) of males claimed to use them. The results of the case-control study bear out these claims; parasite rates were identical (1.9%) for female (18/972) and male (16/858) net users, while for non-users the rates were 4.2% (179/4224) for females and 5.3% (150/2805) for males.

There was no evidence of bias in the use of bednets by any particular age group ( $\chi^2 = 12.7$ ,  $df = 10$ ,  $P = 0.24$ ).

### Annual incidence of malaria

Between 1991 and 1994 the annual incidence of malaria (PCD records) fell from 597 per 1000 to 78 per 1000 population (Fig. 2). In 1991 no spraying operations were carried out, but in 1992 the two villages were sprayed with malathion; in 1993 Baghicha was sprayed with lambda-cyhalothrin and Kagan with

Fig. 2. Annual incidence of malaria in Baghicha and Kagan refugee villages, 1991-94.



malathion; and in 1994 Baghicha was sprayed with malathion and Kagan with lambda-cyhalothrin.

### Discussion

The initial PIB trial conducted in 1991 was successful, with the incidence of malaria in the intervention group reaching only 47% of that in the control group (2). Our optimism continued during the following year since 86% of trial families volunteered to have their nets re-impregnated and a further 15% of refugee families bought bednets. While these levels demonstrate the popularity of the new technique, they could also reflect the community's alarm at the rising trend in malaria, whose annual incidence had risen to 597 cases per 1000; also, the study villages had not been sprayed with insecticide for 2 years. Between 1992 and 1994, however, annual spray campaigns with malathion and lambda-cyhalothrin were renewed to protect the families that lacked bednets. Together with PIBs, this reduced the overall incidence of malaria by 87%, to 78 cases per 1000 per year (4). The lower bednet re-impregnation rate in 1994 (65%) may well have been a result of the successful integrated malaria control policy, which used a combination of PIB, house spraying, and case detection by village health workers. With the chances of contracting malaria being so much lower in 1994, the reduction in re-impregnation rate was neither surprising nor unduly disappointing.

The protection conferred by PIBs was estimated using case-control and prevalence survey methods applied to various categories of bednet owners or users. Direct questioning of symptomatic outpatients

indicated that regular users were almost five times less likely to contract falciparum malaria (odds ratio = 0.22) and three times less likely to contract vivax malaria (odds ratio = 0.31). These are greater reductions in the incidence of clinical, parasitaemic episodes than those obtained using PIBs in Africa (5, 6) and south-east Asia (7), and are more comparable to results from China (1), possibly because of the lower vectorial capacities of South Asian malaria vectors (8). PIBs appeared to offer less protection against vivax malaria, but this might have been an anomaly caused by relapses.

An alternative method of estimating protective efficacy, based on health centre family code numbers and bednet distribution/sales records, produced lower values than those obtained by direct questioning since not all members of families that owned bednets necessarily used them.

The results of parasite prevalence surveys in randomly selected PIB and non-PIB families showed a similar trend to that from PCD records. But by 1994, parasite prevalences had been so reduced by annual house spraying campaigns that a significant difference between bednet owners and non-owners was not apparent. Nevertheless, the majority of bednet owners continued to use their nets to good protective effect against malaria. Indeed, the results of the case-control study indicate that a community-wide PIB implementation campaign could, in a single year, have the same effect as 2 years of house spraying. The study confirms that in areas such as Afghanistan, where the cost and level of organization required to conduct spraying campaigns would be prohibitive, a community-based PIB programme should be adopted as the norm.

It may be significant that families who failed to re-treat their nets appeared to be no less protected than those who did so. There are two possible explanations; the bednet rather than the insecticide might be the crucial protective factor prevailing in the study region or residues of permethrin from previous treatments were still providing sufficient protection (9). Irrespective of the explanation, the finding is important, because the logistics required to achieve a high annual re-treatment rate in Afghanistan — where PIBs are being sold widely — is not trivial. The possible protective efficacy of untreated nets warrants closer examination.

Accurate microscopy by health centre technicians, combined with direct questioning of patients, gave an estimate of protective efficacy consistent with more complicated or expensive methods, such as prospective intervention trials (2) or prevalence surveys in intervention and control groups. Local coverage of PIBs and the local impact on malaria, even when introduced to remote areas, can therefore

be estimated by health centre microscopists who catalogue blood film diagnoses according to patients' bednet use practices.

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## Résumé

### Viabilité de l'utilisation des moustiquaires imprégnées de pyréthrianoïde pour la lutte antipaludique dans des communautés afghanes

Une intervention de lutte antipaludique réalisée dans deux villages de réfugiés afghans en 1991 a démontré que les moustiquaires imprégnées de pyréthrianoïde, distribuées gratuitement à 20% des familles, étaient culturellement acceptables et régulièrement utilisées, même lorsque très peu de personnes avaient déjà utilisé des moustiquaires. Par comparaison avec un groupe témoin, l'intervention a réduit l'incidence du paludisme à *Plasmodium falciparum* et *P. vivax* de 61% et 42% respectivement. Entre 1992 et 1995, une série d'études de suivi ont été réalisées pour évaluer la fiabilité à long terme de cette technique pour la lutte antipaludique dans des communautés de réfugiés afghans dans la Province de la Frontière du Nord-Ouest, au Pakistan. En 1992, 86% des propriétaires de moustiquaires se sont portés volontaires pour faire réimprégner celles-ci, et 15% des familles des deux villages ont acheté des moustiquaires aux deux-tiers du prix coûtant. A partir de 1992, 27% des habitants sont retournés en Afghanistan, et des campagnes annuelles de pulvérisation d'insecticide dans les habitations ont été réalisées pour protéger les familles restées dans les villages de réfugiés et qui n'utilisaient pas de moustiquaires. En trois ans, ces campagnes, associées à l'utilisation des moustiquaires imprégnées, ont réduit l'incidence annuelle du paludisme de 87% (de 597 cas à 78 cas pour 1000 habitants). Néanmoins, 65% des familles continuaient à faire imprégner leurs moustiquaires une fois par an avec de la perméthrine. Pour rechercher si les

moustiquaires étaient encore utilisées et conservaient leur efficacité protectrice avec un taux de transmission aussi réduit, nous avons effectué une étude cas-témoins en 1994 sur les malades fébriles ou présentant d'autres symptômes vus dans les centres de santé des villages. Une comparaison de la positivité des lames chez les utilisateurs et non-utilisateurs de moustiquaires a montré que l'utilisation régulière de celles-ci réduisait le risque relatif de contracter un paludisme à falciparum à 0,22 (intervalle de confiance à 95%: 0,09–0,55 et un paludisme à vivax à 0,31 (IC 95%: 0,19–0,51). Aucun biais lié au sexe ou à l'âge n'est apparu dans l'utilisation des moustiquaires ni dans l'effet protecteur. Ces résultats indiquent qu'un programme communautaire d'utilisation des moustiquaires imprégnées est une mesure appropriée de lutte antipaludique dans les régions où des problèmes de gestion ou de sécurité rendent impossibles les campagnes traditionnelles de pulvérisation dans les habitations, et que la couverture de ces programmes et la protection qu'ils confèrent peuvent être évaluées de façon simple et exacte par un microscopiste de poste sanitaire.

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