

Estimation of the dose of Insect Repellent applied to exposed skin

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Introduction

Bite avoidance measures are an important strategy for travellers to minimise the risk of contracting insect born diseases. It is advised that an insect repellent is applied to exposed areas of skin to avoid mosquito bites and should be particularly used when going out after dusk in malaria endemic areas.

The Advisory Committee for Malaria Prevention (ACMP) currently recommend that diethyltoluamide (DEET) at a concentration of 50% is used when visiting malaria endemic areas. A key factor determining longevity of the repellent before reapplication is the applied dose, usually estimated as mg of active ingredient (ai) per cm² of skin. According to well established mathematical models^{1,2} the length of protection from a DEET repellent increases exponentially with applied dose reaching a plateau at around 2mg/cms² of active ingredient. It is reasonable therefore to aim for application concentration of 1-2mg/cms² ai to give an adequate level of protection in most circumstances, so that frequent reapplication is not required. To achieve such a dose from a 50% solution of DEET would require a reasonably generous application such that the skin felt wetted by the product.

There have been few studies that have examined the amount of repellents applied by travelers in normal use. One study conducted by Goodyer and Thrower³ assessed the amounts applied by travellers both in a simulated environment in the UK and in field studies amongst tourists in India and Kenya . This was conducted using the repellents purchased by the travelers and assessing application to the arms and neck.

This pilot study focuses on the use of repellents applied to various parts of the body including the legs, face, neck and arms. It also explores any differences between application using a spray or lotion.

Method

Twelve final year pharmacy students were recruited and gave consent to take part in the study. As this is viewed as a pilot study subjects were not selected for any particular characteristic such as age, gender or previous experience of using repellents. They were asked to attend the sessions wearing short trousers and short sleeved shirt .The body surface area of various parts of exposed skin was estimated as shown in figure 1 and 2.

At the beginning of the session subjects were asked to imagine they were about to go out in the early evening when visiting a malaria endemic area and apply an insect repellent as per the instructions on a bottle of commercially available repellent spray, which they were asked to read. They were then given a spray bottle containing 50% ethanol/water and asked to apply this as per the instructions. They were additionally advised to not apply near the eyes or spray directly into the face. Subjects first applied the solution to one arm and the bottle weighed before and after use. This was repeated after application to a leg, neck and face. The subjects repeated the same procedure but using a solution delivered from a squeeze bottle, after being shown instruction from a lotion repellent product.

Figure 1
Measurement of Body surface area of limbs

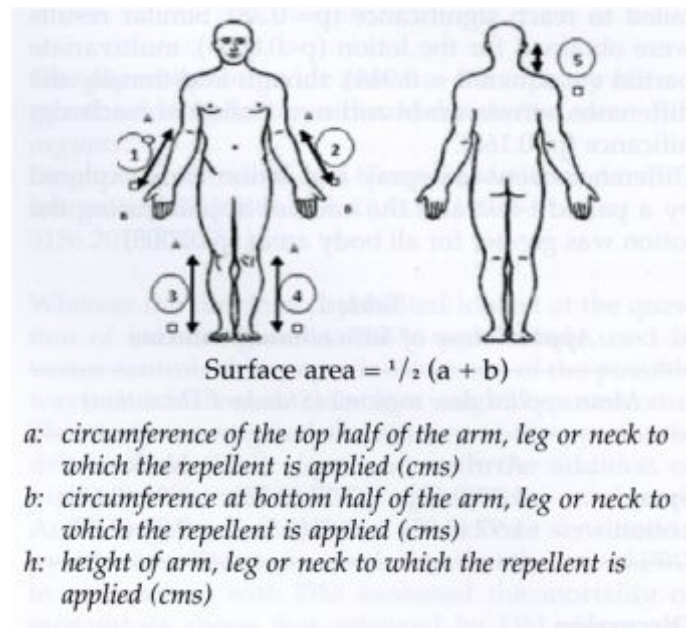
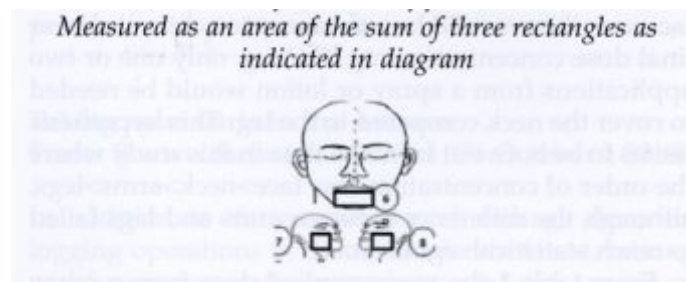


Figure 2
Surface area of face



This study was approved by the De Montfort University ethics committee.

Results

The mean and standard deviation of the applied dose of solution is shown in table 1. Data was analysed using PASW 18 statistical software.

A one-way repeated measure ANOVA was conducted to compare the amount of solution applied to each of the four body areas. For the spray there was a significant effect for body area($p < 0.0005$). The difference between amount applied to the leg and arms failed to reach significance ($p = 0.38$), Similar results were obtained for the lotion ($p < 0.0005$), multivariate partial eta squared = 0.948), though additionally the difference between face and neck failed to reach significance ($p = 0.166$).

Differences between spray and lotion were explored by a paired t-test and the amount applied using the lotion was greater for all body areas ($p < 0.005$)

Table 1
Applied dose of 50% ethanol solution

Mean applied dose mg/cm ² (Standard Deviation)			
	Arm	Leg	Neck
Spray	1.37(0.62)	1.13 (0.35)	1.92 (0.67)
Lotion	1.97 (0.85)	1.61(0.5)	2.94 (0.79)

Discussion

In term of the amount applied to different areas of the body it seems logical that the larger the potential surface area there would be a tendency to achieve a lower final dose concentration mg/cm² e.g. only one or two applications from a spray or lotion would be needed to cover the neck compared to the leg. This hypothesis seems to be born out from the data in this study where the order of concentration was face>neck>arms>legs, although the difference between arms and legs failed to reach statistical significance.

From table 1 the mean applied dose from a spray would not achieve the optimal 1-2mg/cms² a.i. range on either the arms or leg if DEET 50% had been used i.e. the figures in the table would be halved. For the neck and face region adequate levels of repellent are achieved. The dose applied by the use of a lotion is higher for all parts of the body compared to the spray. Some individuals were observed to actuate the spray into the hands for application to the arms and legs whereas others sprayed directly onto the skin surface. The latter method would involve a proportion of the spray not hitting the skin surface so that the dosage may be an underestimate for these individuals. Certainly it appears more likely to achieve a generous application of the lotion by pouring the liquid into a cupped hand before applying to the skin. If the fairly common 20% products are used then the target range would not have been met.

Thrower and Goodyer estimated a mean applied a.i of around 0.5mg/cm² for the arm and 0.7mg/cm² for the neck for 50% DEET products, which is broadly in agreement with the findings for spray application in this study. They found no significant difference between formulations but only 4% of the subjects used a lotion formulation compared to 52% using the spray and most of the others used a solid stick or roll on. It is possible that as only two formulations were used in the present study differences between them could be more readily detected.

This study is limited by the small number of subjects and that this was a simulation rather than observed directly in the field. For instance, Goodyer and Thrower found a higher arm application dosage in field studies in tourists visiting Kenya compared to a simulation in the UK, although the arm dose was still suboptimal. If visiting a malaria endemic area travelers are encouraged to wear long sleeved shirts, though in practice it is likely that many would find this to be too uncomfortable in hot climates. Short trousers are also likely to be worn during the daytime when mosquitoes such as *Aedes sp.* may bite. A further confounding variable is that the subjects knew they were being observed which may motivate to apply higher dosages.

Conclusion

This small pilot study does indicate that travelers are likely to apply suboptimal doses of repellents to the arms and legs using a spray formulation and that higher doses can be achieved with a lotion. Neck and face application appears to be adequate. Further work

is needed in field conditions to explore these findings.

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