Published in final edited form as:

Trans R Soc Trop Med Hyg. 2007 August ; 101(8): 773–776. doi:10.1016/j.trstmh.2007.04.008.

Arithmetic or geometric means of EPG are not appropriate indicators to estimate the impact of control measures in helminth infections

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Abstract

In helminthology, the mean number of eggs per gram of faeces (EPG) is a commonly used indicator for estimating the severity of the infection in a population. The example presented here shows that, in our opinion, mean EPG (either calculated as arithmetic or geometric means) is not the best way to evaluate the impact of control measures, since helminth infections present intensity/ morbidity relationships which should be considered when selecting indicators for the evaluation of control measures. In our opinion, an analysis by class of intensity is more informative.

Keywords

Helminth; ANOVA; non-parametric tests

Introduction

In helminthology, the “number of eggs per gram of faeces” (EPG) is an indirect measure of the number of worms parasitizing an individual. Normally egg counts are over-dispersed in a population (Albonico et al 2006): the majority of the infected individuals present low egg counts, while the minority present a very high egg count.

Individuals presenting high EPG, despite being usually less than 15 percent of the population (Albonico et al 2006), are the ones suffering more from morbidity caused by helminth infections (Albonico et al 2006).

Reduction of egg count in the high intensity infection group is the main aim of any control programme (WHO 2002). The “mean EPG” is a commonly used indicator for the severity of the infection and of the impact of control programmes in populations (Hall and Holland 2000). Mean EPG could be calculated as Geometric Mean (GM) or Arithmetic Mean (AM).

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Conflict of interests

The authors have no conflicts of interest concerning the work reported in this paper.

The example presented here and the following discussion is aimed to explain why in our view, the comparison of mean EPG (calculated using the arithmetic or geometric method) before and after intervention, is not an appropriate indicator for the results of helminth control programmes. The changes in the percentages of individuals with moderate/heavy intensity infection in the population is much more indicative of the effect of a control programme because it provides information on the size of the group suffering more from helminth morbidity.

Material and method

Data from 10 individuals infected by hookworms are presented in the first line of table 1. The EPG values at baseline are over-dispersed with 10 percent of the population having a high intensity EPG count and 10% with a moderate intensity EPG count. In this scenario, the population is receiving two different interventions:

- Intervention A, which reduces by 50% the EPG of the individuals presenting low EPG
- Intervention B, which reduces by 50% the EPG of the individuals presenting moderate/high EPG.

The example is constructed to analyze the performances of AM and GM in assessing the two interventions. We already know from a public health point of view that intervention B is much more beneficial since it reduces the number of parasites in the highly infected group. An intervention that reduces the intensity of infection only in the lightly infected group (intervention A) is of less value.

Results

Table 1 shows the calculation of AM and GM and how the two indicators capture the effects of the interventions:

After intervention A, AM shows an 11% EPG reduction and GM a 42% EPG reduction from the baseline. After intervention B, AM shows a 40% EPG reduction and GM a 12% EPG reduction.

Table 2 presents the different proportions in the population of light, moderate and heavy infection (threshold for hookworm form WHO, 2002). Results from a Chi-square test reveal a significant difference in the results of intervention B from baseline and no significant difference in the results of intervention A.

Discussion

GM was developed to deal with over-dispersed data but specifically to reduce the impact on the mean of large numbers because these were considered “outliers” and therefore less interesting than the rest of the population (Snedecor & Cocrain 1967). However, in helminthology, the “outliers” represented by high EPG counts are the group suffering more

from the morbidity caused by the infections and therefore the most interesting group from the public health point of view.

The calculation of GM includes a logarithmic transformation that normalizes the variance of the data, allowing the use of standard statistical tests to estimate the significance of the result obtained. The homogeneity of the variance among the groups that are compared (or “homoscedasticity”) is one of the essential conditions for the application of parametric tests (Cochran & Cox 1992) that are simple to perform and to interpret. However, in our example the mathematical procedures applied to normalize the variance distort the data in a way that their interpretation became problematic from the public health point of view.

In the example in Table 1, GM shows a statistical significance for the results of intervention A that has effect only on low EPG counts and therefore has a very low effect on morbidity, and on the contrary, is not capturing the significance of intervention B that is clinically significant. For the performances obtained in this example, GM, is not an accurate indicator for evaluating the effects of helminth control measures.

As indicated by Dash et al (1988) in a study evaluating the value of GM and AM in helminth control activities in the veterinary field, AM is better at capturing the results of control interventions because the mean calculation is not affected by the logarithmic/exponential transformation of the data applied to GM.

In the example presented in Table 1, AM shows a more drastic reduction in EPG after intervention B compared to intervention A. However, when we want to evaluate the statistical significance of the results, we cannot apply a parametric test (like the ANOVA) because the untransformed EPG data do not fulfil the assumption of homoscedasticity (Cochran & Cox 1992). A violation of the ANOVA assumptions produces a distortion of the F test and the result cannot be interpreted directly. (Chiarotti 2002). For this reason, despite the fact that the AM captures the differences between the two interventions, we do not consider it a suitable indicator for evaluating the effects of control measures if utilized alone.

In our opinion the best way to represent and evaluate the intervention results is analyzing the changes that occur in the different categories of intensity as in Table 2. This method highlights the significance of intervention B and the limited value of intervention A.

Conclusions

EPG count in helminth infections presents a distribution/morbidity relationship, that need to be taken into account when selecting indicators to assess the impact of control measures

For these reasons, our assessment concludes that the indicator most commonly used to evaluate the effects of intervention in helminth infection: the reduction of mean EPG after intervention, either calculated as GM or AM, is not the most effective.

An evaluation of the changes in the class of intensities, similar to Table 2, clearly highlights changes occurring in the group suffering the highest morbidity and therefore is a more appropriate indicator for managers of helminth control programmes.

Some problems in interpreting the results of interventions using classes of intensity could also arise due to thresholds: For example, in the case of very high intensity (i.e. > 10 000 EPG in case of hookworms) a 50% reduction in EPG would not result in a change of category for the individual (the threshold between moderate and high intensity is 4 000 EPG) or, on the other hand, a small change that would allow the EPG count to cross the threshold (from 4 100 EPG to 3 900 EPG) may be overestimated using this method.

We therefore conclude that a proper evaluation should be carried out using a combination of two methods:

- Arithmetic mean to evaluate, from the public health point of view, the reduction of EPG in the community (any reduction of over 50% is certainly clinically valid from a public health perspective).
- An evaluation of the changes in the class of intensities (to be able to apply a proper statistical test and evaluate the statistical significance of the reduction).

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Table 1

Calculation of arithmetic mean and geometric mean of EPG in three different situations:

Baseline - Over dispersed distribution of EPG at baseline

A - Results after an intervention reducing 50% of egg output only in low egg counts

B - Results after an intervention reducing 50% of egg output only in Moderate/high egg counts.

	EPG (Egg Per Gram) at Baseline													Reduction from baseline	
Baseline	Arithmetic mean (SD)		172	240	2400	24	48	24	1200	96	24	4800	903		
	Geometric mean		(Total egg output/n) 9028/10												
	Log transformation(SD)		2.24	2.38	3.38	1.38	1.68	1.38	3.08	1.98	1.38	3.68			
			(Sum of Log/10) 22.56=2.256												
	Exponential transformation		10 ^{2.256}												
A	EPG after intervention A		86	120	2400	12	24	12	600	48	12	4800		11%	
	Arithmetic mean (SD)		(Total egg output /n) 8114/10												
	Geometric mean														
	Log transformation(SD)		1.93	2.08	3.38	1.079	1.38	1.08	2.78	1.68	1.08	3.68			
			(Sum of Log/10) 20.15/10=2.015												
B	Exponential transformation		10 ^{2.015}												42%
	EPG after intervention B		172	240	1200	24	48	24	120	96	24	2400			
	Arithmetic mean(SD)		(Total egg output /n) 5428/10												
	Geometric mean														
	Log transformation (SD)		2.24	2.38	3.08	1.38	1.68	1.38	3.08	1.98	1.38	3.38			
		(Sum of Log/10) 21.96/10=2.196												12%	
Exponential transformation		10 ^{2.196}													

* ANOVA not possible because variance not normally distributed

** Significant difference

Table 2

Percentages of infected individuals in each class of intensity at baseline and after intervention A and B.

	Class of intensity*		
	Light intensity 1-1999 EPG	Moderate intensity 2000-3999 EPG	heavy intensity >4000 EPG
Baseline	80%	10%	10%
Intervention A	80%	10%	10%
Intervention B	90%	10%	0% **

* Classes of intensity for hookworms (WHO 2002)

** P<0.01 from baseline (assuming a sample size of 100 individuals)