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Review Article

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Evaluation of Public Health Mass Campaign: Hesitancy and Event Ratios Method

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Abstract

Several public health interventions administer drugs and vaccines to large number of people for preemptive or reactive intervention. These vaccines and drugs were developed in very narrow conditions in clinical trials and we therefore have to continuously monitor the efficacy in the field. This paper proposes a method to evaluate the efficacy in the field using data collected from the intervention coverage survey and surveillance. The design is closely related to cohort prospective studies except that the sample size is not fixed upfront and the measure of association not affected by the population denominator.

It uses two new terms: hesitancy ratio denoted β, which is the ratio of the target that does to receive the intervention to the target that received it; event ratio is denoted by α is the ratio of health event or disease being prevented absolute incidence in the intervention group to that is in control group. It further shows that risk ratio (RR) can be calculated from these two parameters by taking their products. i.e. RR = α β. This method is therefore called Hesitancy and Event Ratios (HER) Method.

We can conclude that this method is scientifically sound and can be used in the evaluation of public health intervention in the field. We recommend that this method be included in routine monitoring of programs for efficacy evaluation.

Keywords:

Survey, Surveillance, Hesitancy Ratio, Event Ratio, Efficacy, Evaluation, Public Health, Mass-Campaign

Introduction

The process of vaccine and drugs development is very rigorous from the preclinical studies to clinical trials during which the toxicity and the efficacy of the substance in question is investigated [1, 2]. Generally, the number of participants used to investigate a new candidate vaccine/drugs is large enough to statistically make conclusions on it toxicity and efficacy but equally small enough for the investigator to strictly respect all recommended conditions for conservation and administration using small logistics and qualifed personnel [3-5]. As the time taken to investigate a candidate vaccine/drugs is usually very small, it is believed that some rare serious adverse effects may not be detected during clinical trials but which can become more frequent when the drug is used in large number of people or long time after drug use [6-8].

Several public health interventions use vaccines or drugs that have been developed, investigated, and approved in very narrow conditions through clinical studies [9-11]. Examples include but not limited to Oral Cholera Vaccine (OCV) use for reactive or pre-emptive mass campaign against cholera; Ivermetin used in mass administration against Onchocerciasis, vaccines for vaccination campaigns like measles vaccine, Yellow Fever vaccine, Meningitis vaccine, etc. During public health intervention, the respect of all conditions that the vaccine was tested such as conservation, dosage, administration route and even the qualification of sta cannot be garantee at all times [12-14]. Because of this, the effectiveness of the molecule and the incidence of adverse effects might not always be same that was observed during clinical studies.

Due to these possible disparity between the conditioons of clinical studies when drugs and vaccines are tested and the field where public health interventions are organised, it is clearly emperative to continuously design and conduct studies for the assessment of these public health interventions in terms of impact, effectiveness

and cost-e ectiveness. We must recognise that some often, using such a drugs/vaccine for mass administration preceed a fieldeld study. However, a few does not pass through the field trial stage before use and besides the profile of the germs against which the vaccine or drugs was developped might have changed leading to resistance.

Several study designs exist to evaluate the effectiveness and impact of public health interventions [15]. However, this paper does not intend to enumerate these methods but rather to describe a new approach that can be used in the field to determine the effectiveness of public health interventions that involve mass administration of drugs and vaccines. This method is called Hesitancy and Event Ratios (HER) Method and it might be less expensive since it simple involves the combination of traditional monitoring methods with particular approach in data analysis. To better demostrate HER method, we will use the Oral Cholera Vaccination (OCV) campaign against cholera as an example throughout this paper.

Technical Description and Analysis

Underlying Principles

In order to make this section very clear and easily understandable, we will logically derive our underlying principles from a well-known epidemiological concepts (Risk Ratio). If we take for instance a clinical trial in which OCV is being tested using one group of participants that recieve OCV and the other group that receive a placebo. The two groups are followed up for say 12 months and the incidence of cholera recorded. The measure of association that can be used in this case to estimate the strength of the relationship between OCV and cholera can be the risk ratio (RR) [15]. By definition, RR is the ratio of the probability of cholera incidence in the group that received OCV (I_1) to the probability of cholera incidence of cholera in the placebo group (I_1) [16-18]. i.e.

$$RR = \frac{I_1}{I_2}$$

However, the event(cholera) incidence in each group is given by the number of cases of cholera recorded in the group (y_i) divided by the group size (n_i). i.e.

$$I_i = \frac{y_i}{n_i}$$

This implies that equation (i) above can be rewritten as equation (iii)

$$RR = \frac{y_1/n_1}{y_2/n_2} = \frac{y_1 n_2}{y_2 n_1} = \frac{y_1}{y_2}.\frac{n_2}{n_1}$$

For convenience, we shall call the fraction, y_1/y_2 = event ratio denoted as α and n_1/n_2 hesitancy ratio denoted as β. Event ratio is called as such because it represents the ratio of absolute incidence of event of interest in the two groups and hesitancy ratio is called as such because we consider that in public health intervention, we usually target all eligible persons in the community and when we do not reach everybody with an intervention it might mean there is hesitancy from the beneficiaries. Equations i and iii can be therefore be rewritten as equation iv.

$$RR = \alpha\beta$$

NB. An alternative to demonstrate this relationship could be to go through the 2x2 contingency table.

In the subsequent sections, we will be focused on how to estimate the values of event ratio (α) and hesitancy ratio (β) in a specific public health intevention. In fact, the event ratio will be estimated through the surveillance system and hesitancy ratio from the post-campaign coverage survey.

Estimation of the Hesitancy Ratio

In order to estimate the value of hesitancy ratio (β), it will be very important to conduct a community based survey using a representative sample from the population to determine the coverage of the public health intervention in question. For instance, immediately after the mass administration of OCV, the coverage is estimated using a survey. Not to go into details of how to conduct the survey but it is imperative that a representative sample and appropriate sample size be used to ensure an unbiased estimation of the target population proportion that received the OCV. If we consider the total target population for OCV in a particular population say IDP camp to be N, then the proportion of target population that received OCV (denoted μ1) will be calculated as follows:

$$\mu_1 = \frac{n_1}{N}$$

Equation v implies that,

$$n_1 = \mu_1 N \quad \ldots\ldots\ldots\ldots \text{(vi)}.$$

In the same manner, we can equally derive the proportion of the target population that did not receive OCV as (μ_2)

$$\mu_2 = \frac{n_2}{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{(vii)}$$

Equation vii implies that,

$$n_2 = \mu_2 N \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(ix)}$$

Note that the sum of the number of targets that received OCV and the number of target population that did not received gives the total number of target population in the population. This means that. It can therefore be demonstrated from the above that $1= u_1+u_2$; $u_2= 1-u_1$ The hesitancy ratio from equation (ix) can thus be rewritten as in equation (x)

$$\beta = \frac{1-\mu_1}{\mu_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(x)}$$

Using a large sample size and a representative sample from the target population, the coverage of OCV estimated from the sample denoted as p will approximate to μ1 [19-23]. Substituting in equation x gives equation xi which is a close approximation of hesitancy ratio from the sample.

$$\beta = \frac{1-p}{p} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(xi)}$$

Reading through this, one may surely ask questions such as why must we conduct a survey to estimate this coverage? Why not use the population denominator used in planning in intervention and the number of persons reached by the team to estimate the value of β? These questions are very genuing but unfortunately using

the target population and the number of individual reached during the intervention may be a source of serious bias that can lead to incorrect conclusions at the end of the study. This is so because of the follow reasons:

- The population denomintor used in planning public health intervention might not be very correct. Using a target population that is signicantly more or less that, the real target size will both lead to biased value of β [24].
- During public health interventions, the field teams sometimes administer the intervention to individuals out-of the intended target population of the intervention. This sometimes can happen because of the urge of the teams to meet their daily targets but could also happen that the population realy wish to benefit from the intervention that they may lie about some basic inclusion parameters such as age [25].
- Some times when public health campaign is organised to target a very serious public health problem like say a reactive Oral cholera vaccination in a population, people from neighbouring areas living at a reasonable distance can cross to receive. This is never capture so during the campaign and can be a source of bias for coverage estimation [24-26].

Estimation of the Event Ratio

The event ratio (α) is defined as the ratio of absolute incidence of event (say cholera) in exposed(OCV) group to incidence of event in unexposed (placebo) group. To estimate α, it is recommended to use the surveillance system in place but of course adapting it to collect all necessary information in an unbiased approach. For instance, consider the situation of Oral cholera vaccination used for the prevention of cholera in a community, the event being prevented here is cholera and surveillance should aim to detect cholera cases throught out the supposed effective period of the vaccine. For each case of cholera detected, information will be collected if they received OCV or not.

By definition, $\alpha = y_1/y_2$ ……...(xii) where y1 and y2 are the absolute incidences of event or disease(cholera) in intervention and control groups respectively. If we assume that the surveillance system will detect just a fraction of the cases, this fraction is unknown but let it be k. Assuming that the surveillance data is unbiased, meaning that the fraction k1 in intervention group is same as the fraction k2 in control. We shall denote the number of cholera cases detected by the surveillance system that received OCV to be x1 and the number that did not receive OCV x2.

This implies that, $y_1 = kx_i$……xiii. Substituting in equation xii, give equation xiv.

$$\alpha = \frac{y_1}{y_2} = \frac{kx_1}{kx_2} = \frac{x_1}{x_2}$$

Estimating the confidence interval of RR

Now that we have clear demonstrated how to estimate the RR from this study design, it is important to proceed on how we can calculate the confidence interval (CI) for the RR. In order to proceed from here, we will use the data obtained from the survey and the surveillance to draw a 2x2 contingency table on which standard formulas will be used to derive the CI. Typically, the contingency table is written as follows table 1.

Table1: a sample 2x2 table that can be drawn from HER Method

Presence of event		Absence of event	Total
Exposed group	y_1	y_1-n_1	n_1
Unexposed group	y_2	y_2-n_2	n_2
Total	y_1+y_2	N-y_1-y_2	N

It is important to note that y1 and y2 are obtained from our surveillance data directly as shown in section 2.3. For n_1 and n_2 we shall derive both from the coverage of the intervention calculated from survey (p) and the total target population (N) for the public health intervention. i.e. $n_1 = pN$ and $n_2 = (1\text{-}p)\,N$ were p is the coverage of the health intervention obtained from the survey results. Once the data for table 1 are obtained and arranged as such, the calculation of the standard error (SE), confidence interval as follows:

$$SE(RR) = e^{\sqrt{\frac{1}{y_1}+\frac{1}{y_2}-\frac{1}{n_1}-\frac{1}{n_2}}} \quad \text{……(xv)(27)}$$

$$(1-\alpha)\%\ CI\ (RR) = RR \pm Z_{\alpha/2} SE(RR) \quad \text{…. (xvi)(28–30)}$$

Discussion

This article suggests a new approach in evaluating public health mass intervention in the field. It makes use of the post-campaign coverage survey and surveillance with a particular focus on how to pool the data statistically to estimate the strength of association (risk ratio) and its corresponding confidence interval (CI).

Many population-based public health interventions such as vaccination campaign against cholera is usually accompanied by post-campaign survey to estimate the coverage of the campaign and strengthening of surveillance for impact assessment [26-33]. This paper proposes that just a little effort in data pooling and analysis can be used to monitor the efficacy of the drugs/vaccines used in the campaign. The advantage of this method is that it uses readily collected for other purposes and that the estimate of the RR is not affected by the wrong estimation of the population denominator. It is simply imperative to ensure that the sample for survey is selected randomly and that the surveillance is sensitive and unbiased [5, 22, 23]. However, the estimate of the standard error (SE) and confidence interval (CI) for the RR are dependent on the correct estimate of the population denominator. However, it can be demonstrated mathematically that when the difference between the estimated target population and the real target population is not very great SE and CI well not too much deviate from their real values [34-37].

Intuitively, this method adopts the same design as cohort prospective studies except that the sample size for the two study arms are not known in advance and are simple estimated thereafter [38]. With integration into surveillance and survey, this method would appear to be very cost effective compared to standard clinical trials organized to evaluate the efficacy of the intervention. However, it cannot be used to investigate a new product that has not been approved for use due to the mass administration and potential risks associated if the product causes serious adverse effects.

Conclusion

Hesitancy and Event Ratios Method is demonstrated theoretically

to be suitable for the evaluation of population based public health interventions. The measure of association (risk ratio) with the standard error and confidence interval can be estimated to the closest approximation. Using HER method can be very cost effective since it simple pools data from survey and surveillance to evaluate the efficacy of the intervention. However, this cannot be used to investigate a new drug that has not be approved is it can turn out be more expensive or not cost effective if used only for the efficacy evaluation purpose. We recommend that this should be integrated in the routine program monitoring to constantly have updated information on intervention efficacy.

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