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Probability distribution of children according to sex in a random population of families

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***Abstract*—** The number of male children and female children are collected from 400 two-child families which belong to a random population. The main objective of this research paper is to fit the binomial probability distribution using chi-square analysis. In this particular paper, the presence of two male children in a family is considered as "success" and the presence of two female children is considered as "failure". The probability of the resulted χ^2 value is calculated. This P-value is less than the hypothetical P-value that is obtained from the χ^2 distribution table. Hence, the data analysis holds true in case of this observed data.

Keywords— chi-square, probability, binomial distribution

I. Introduction

Probability is the measure of the likelihood that an event will occur. The higher the probability of an event, the more likely it is that the event will occur. The binomial distribution model is an important probability model that is used when there are two possible outcomes (hence "binomial"). These are just a few examples of applications or processes in which the outcome of interest has two possible values (i.e., it is dichotomous). The two outcomes are often labeled "success" and "failure" with success indicating the presence of the outcome of interest. This terminology is typically used when discussing the binomial distribution model. As a result, whenever using the binomial distribution, we must clearly specify which outcome is the "success" and which is the "failure". [ref 3]

II Methodology

From a random population, the number of males and females in case of two-child families are collected. Along with this information, the number of families having two sons, one son and one daughter and two daughters (no sons) are also counted. The number of male births is taken as "success". Consequently, the number of female births is regarded as "failure". After the collection of data, the success probability (p) and the failure probability (q) are calculated. From the obtained results, the expected values of the number of families having two sons, one son and one daughter and two daughters are calculated.

Now, chi –square (χ^2) analysis is performed. The analysis is done at 5 %(0.05) level of significance. The probability of the resulted χ^2 is then calculated. [Ref 1]

Calculations –

p = Number of males / Total number of children

= 411/ 800 = 0.51375

q = (1 – p) = 1 – 0.51375 = 0.48265

Expected values –

Expected number of families with two sons = $p^2 * N = (0.51375)^2*400 = 105.57$

Expected number of families with one son and one daughter = 2pq = 2*0.51375*0.48625

= 199.85

Expected number of families with two daughters = $q^2 * N = (0.48625)^2*400 = 105.57$

Observed values –

Observed number of families with two sons = 104

Observed number of families with one son and one daughter = 203

Observed number of families with two daughters = 93

$$\chi^2 = \sum \frac{(\text{Observed value} - \text{Expected value})^2}{\text{Expected value}}$$

Degrees of freedom = n-1; where n = number of categories/ sample size

= 3-1 = 2

Tables

	Expected value	Observed value
Number of families with two sons	105.57	104
Number of families with one son and one daughter	199.85	203
Number of families with no sons/ two daughters	94.58	93

χ^2 – value	Degrees of freedom	Probability/ P-value
0.0993	2	0.9515

Results

The χ^2 and the P-value of this data are 0.0993 and 0.9515 respectively. Therefore, the resultant χ^2 value follows the χ^2 distribution with n-1(2) degrees of freedom

Discussion

According to the χ^2 distribution table, the probability at 0.05 level of significance is 5.99. If the calculated χ^2 value is lesser than the hypothetical table value, then the assumptious association is considered to be true. Since the calculated χ^2 value(0.0993) is less than 5.99(probability = 0.9515), the above objective is fulfilled, i.e., the probability of a family having two male children/ two female children is 25% each, whereas the probability of having one male and one female child is 50%.

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