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1. **CONTINGENCY TABLE**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatment | Alive, n (%) | Died, n (%) | Total, n |
| Placebo | 13,099 (97.8%) | 290 (2.2%) | 13,389 |
| Vitamin A | 13,499 (98.3%) | 233 (1.7%) | 13,732 |
| Total | 26,598 (98.1%) | 523 (1.9%) | 27,121 |

**Summary:**  
Among the children who received the placebo, mortality rate at sixteen months was observed to be 2.2%, compared with 1.7% among those who received Vitamin A. This shows a modest reduction in child mortality associated with Vitamin A supplementation.

R Code Used in constructing the 2x2 contingency table:

CT <- table(nepal621$trt, nepal621$status)

addmargins(CT)

prop.table(CT, margin=1)

1. **PROBABILITY CALCULATIONS**

|  |  |  |
| --- | --- | --- |
| Category | Event | Probability |
| Marginal | Pr(VitA) | 0.5063 |
| Pr(Died) | 0.0193 |
| Joint | Pr(Died and VitA) | 0.0086 |
| Pr(Died and Placebo) | 0.0107 |
| Conditional | Pr(Died | VitA) | 0.0170 |
| Pr(Died | Placebo) | 0.0217 |

**R Code Used in Calculating probabilities**

n <- sum(CT)

pr\_vita <- sum(CT["Vit A", ]) / n

pr\_died <- sum(CT[, "Died"]) / n

pr\_died\_vita <- CT["Vit A", "Died"] / n

pr\_died\_placebo <- CT["Placebo", "Died"] / n

pr\_died\_given\_vita <- CT["Vit A", "Died"] / sum(CT["Vit A", ])

pr\_died\_given\_placebo <- CT["Placebo", "Died"] / sum(CT["Placebo", ])

Using Bayes' Theorem

Pr(VitA | Died) = [Pr(Died | VitA) × Pr(VitA)] / Pr(Died)

Numerator: Pr(Died | VitA) × Pr(VitA) = 0.0170 × 0.5063 = 0.0086

Denominator: Pr(Died) = 0.0193

Result: Pr(VitA | Died) = 0.0086 / 0.0193 = **0.4455**

1. **SEX AS THE EFFECT MODIFIER**

2x2 Contingency tables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment | Sex | Alive, n (%) | Died, n (%) | Total, n |
| Placebo | Female | 6,376 (97.5%) | 166 (2.5%) | 6,542 |
| Male | 6,723 (98.2%) | 124 (1.8%) | 6,847 |
| Vitamin A | Female | 6,544 (98.2%) | 121 (1.8%) | 6,665 |
| Male | 6,955 (98.4%) | 112 (1.6%) | 7,067 |

Treatment Effects:

Males: 0.0181 - 0.0158 = 0.0023

Females: 0.0254 - 0.0182 = 0.0072

Difference: |0.0023 - 0.0072| = 0.0049

**Summary:**  
In the placebo group, mortality was 2.5% among females and 1.8% among males. In the Vitamin A group, mortality was 1.8% among females and 1.6% among males. Thus, Vitamin A supplementation reduced mortality in both sexes. This difference suggests evidence of effect modification by sex: Vitamin A supplementation had a stronger protective effect against mortality among girls than among boys. Quantitatively, the difference in treatment effect between sexes was approximately 0.5 percentage points.

**R Code Used**

nepal\_plac <- filter(nepal621, trt == "Placebo")

nepal\_vit <- filter(nepal621, trt == "Vit A")

CT\_plac <- table(nepal\_plac$sex, nepal\_plac$status)

addmargins(CT\_plac)

prop.table(CT\_plac, margin=1)

CT\_vit <- table(nepal\_vit$sex, nepal\_vit$status)

addmargins(CT\_vit)

prop.table(CT\_vit, margin=1)

1. **A) VITAMIN A SUPPLEMENTATION HAS NO EFFECT ON MORTALITY**

H₀: Vitamin A supplementation has no effect on mortality (OR = 1)

H₁: Vitamin A supplementation affects mortality (OR ≠ 1)

Statistical Test employed: Binary Logistic Regression

R Code Used

Ho\_1 <- glm(status == "Died" ~ trt, data = nepal621, family = binomial)

summary(Ho\_1)

Table: Logistic Regression Results - Overall Treatment Effect

|  |  |  |  |
| --- | --- | --- | --- |
| Category | Odds Ratio | 95% CI | p-value |
| Intercept (Placebo) | 0.022 | 0.020 - 0.025 | 0.0000 |
| Treatment |  |  |  |
| Vit A | 0.780 | 0.655 - 0.928 | 0.0051 |
| Placebo | Ref |  |  |

Decision: Reject the null hypothesis as p-value is less than 0.05

**B) TREATMENT EFFECT IS THE SAME FOR BOYS AND GIRLS**

**R Code Used**

Ho\_2 <- glm(status == "Died" ~ trt \* sex, data = nepal621, family = binomial)

summary(Ho\_2)

**Table: Logistic Regression Results – Treatment Effect Modification**

|  |  |  |  |
| --- | --- | --- | --- |
| Category | Odds Ratio | 95% CI | p-value |
| Intercept (Placebo, Male) | 0.026 | 0.022 – 0.030 | 0.0000 |
| Treatment |  |  |  |
| Vit A | 0.710 | 0.560 – 0.900 | 0.0046 |
| Placebo | Ref |  |  |
| Sex |  |  |  |
| Female | 0.708 | 0.560 – 0.896 | 0.0041 |
| Male | Ref |  |  |
| Interaction |  |  |  |
| Vit A × Female | 1.229 | 0.866 – 1.745 | 0.2475 |

Despite the observed difference in treatment effects between sexes, there is insufficient statistical evidence to conclude that sex significantly modifies the treatment effect (p-value = 0.248)

1. **Binomial probabilities hand calculations**

For males on placebo:

* Alive = 6723
* Died = 124
* Total = 6847

= 0.01811012.

Binomial probability:

Calculations (n)

(no boy dies)

Pr(*X* = 0) = **0.946648**

**(**Exactly one boy dies)

Pr(*X* = 1) = **0.052380**

(exactly two boys die)

Pr(*X* = 1) = **0.000966**

**(**all three boys die)

1. **POISSON ESTIMATION OF THE BINOMIAL**

Using the male-specific mortality rate from (v) above,

Poisson approximation to the binomial for

Mean,

For ,

0 deaths:

1 death:

2 deaths:

3 deaths:

1. **AGE-SPECIFIC MORTALITY RATES**

R Code Used

CT\_placebo <- table(nepal\_plac$age, Nepal\_plac$status)

addmargins(CT)

prop.table(CT, margin=1)

CT\_vita <- table(nepal\_vit$age, Nepal\_vit$status)

addmargins(CT)

prop.table(CT, margin=1)

Table: Mortality by Age Category and Treatment Group

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment | Age Category | Alive, n (%) | Died, n (%) | Total, n |
| Placebo | <1 | 2,495 (95.4%) | 120 (4.6%) | 2,615 |
| 1–2 | 5,385 (97.8%) | 119 (2.2%) | 5,504 |
| 3–4 | 5,219 (99.0%) | 51 (1.0%) | 5,270 |
| Vitamin A | <1 | 2,657 (95.9%) | 114 (4.1%) | 2,771 |
| 1–2 | 5,561 (98.4%) | 92 (1.6%) | 5,653 |
| 3–4 | 5,281 (99.5%) | 27 (0.5%) | 5,308 |

**Given that:**

Age group: 1-2 years (18 months falls in this category)

Treatment: Vitamin A

Mortality rate (p): 0.0163

**R Code Used & Output**

> Pr\_Mortality <- 0.0163

> (1 - Pr\_Mortality)^2 \* Pr\_Mortality

[1] 0.01577295

> dbinom(1, 3, Pr\_Mortality)

[1] 0.04731885

1. Probability that J, K live and L dies is **0.01577295**
2. Probability that exactly one dies is **0.04731885**

The two values are not the same because they represent different situations. The probability that J and K live while L dies looks at only one specific outcome among the three children. In contrast, the probability that exactly one child dies covers all possible ways this could happen whether it is J, K, or L who dies. Since each of those three outcomes has the same probability, you have to add them together. That’s why the overall probability of exactly one death is three times larger than the probability of just one specific child dying.