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Impact of Power Outages on Developing Countries: Evidence from Rural Households in Niger Delta, Nigeria

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Abstract
Nigeria is suffering from the worst energy crisis in its history, resulting in its rural communities being subjected to massive power outages, daily. Energy promotes economic well-being and makes social life worthwhile such that youths are less disposed to violent crimes. This study investigated the consequences of power outages on the social-economic life of rural households in the Niger Delta region of Nigeria. Primary data were collected through a semi-structured questionnaire circulated among unemployed youth, students, housewives, businessmen and professionals in the area. The study focused on the relationship between power outage and its impact on the everyday life of the people. This study adopted a descriptive research design using 1000 randomly selected members of 44 rural households in the areas mostly affected by incessant power outages. It was found that stunted economic growth, reduced leisure time as well as heightened criminality and insecurity are some of the major results of rampant power outages among rural households in the Niger Delta. It is concluded that power outages have severe negative impact on the social and economic lives of the people. The findings from this research would help improve the outlook of rural communities in Nigeria and other developing countries.
Keywords: Nigeria, Power outage, Energy, Electricity, Rural households

1. Introduction

Power outage is the state of complete absence of electricity at the consumer's end (CEIDS, 2001). This phenomenon comes in different forms – planned, unplanned, unanticipated faults and burnouts. Generally, power outages are as a result of gross shortage of energy. Energy poverty implies the lack of or limited access to energy resources like electricity, gas, fuel, kerosene and diesel. It describes a situation whereby supply of energy services and goods fall below demand or expectations.

Energy poverty is a perennial problem among most developing countries including Nigeria. Statistics shows that 1.4 billion people, about one quarter of the world population have no access to electricity and that a further 1 billion lack reliable access. Interestingly, 80% of these are in South Asia and Sub-Saharan Africa (IEA, 2002; IEA, 2011). Record has it also that four out of five people without electricity live in rural areas of the developing countries. Only 5% of sub-Saharan rural populace, for instance, has access to electricity (Davidson and Mwakasonda, n.d.). Many people in the world today rely on traditional bio-mass wood, agricultural residues and dung for cooking and heating owing to shortage of modern fuels.

Electricity provides lighting in households and powers appliances thus extending the day and providing additional hours for reading and work. The presence of electricity has huge impacts on education as well. The usage of electricity for heating and cooking saves women and children many hours of work. Most households in developing countries rely heavily on wood fuel which negatively impacts their health and social–economic status (Cerny, 2013). In developing countries also, women spend much time to gather wood or other biomass for cooking or heating due to the absence of modern energy including electricity. In India, two to seven hours each day are spent in the collection of fuel for cooking. This reduces the time which ought to have been devoted to other productive activities, such as farming and education. Electricity is essential to the healthcare sector because all modern health appliances are fully dependent upon it [IEA (2002), World Bank (2008)].

Energy crisis is undeniably a major impediment to growth and development in most areas of the world because many countries seeking to develop and become industrialized must first address their energy challenges so as to have readily available adequate and affordable energy goods and services. Electricity is key to socio-economic and technological development as recognized by the Millennium Development Goals and the World Summit on Sustainable Development. Electricity makes life worthwhile in a modern society such that the increased consumption of energy, particularly commercial energy like electricity now symbolise high economic status of a country (Aladejare, 2014).

1.2. The study area

About 50 million people live in the Niger Delta (29% of Nigeria's total population), 62% of them are below the age of 30. The region comprise of nine out of the 36 Nigeria's federating states and represents about 12% of Nigeria's total surface area. It is heterogeneous with over 40 different ethnic groups and more than 250 languages and dialects. The region is in the southern part of Nigeria and bordered to the south by the Atlantic Ocean and to the East by Cameroon. The nine Niger Delta states are: Rivers, Bayelsa, Edo, Delta, Cross River, Ondo, Imo,

Abia and Akwa Ibom.

Table 1: Distribution of employed working population by activity and region 2005

State	Agric.	Fish.	Manuf.	Constr.	Trade	Transp.	Pub Admin.	Educ.	Health/ Social work	Sces	Other
Abia	44	0	4	3	25	4	4	4	1	9	2
Akwa Ibom	35	2	2	2	26	5	4	3	1	20	1
Bayelsa	34	19	3	4	16	2	7	8	3	4	2
Cross River	68	0	1	1	9	2	5	5	2	6	1
Delta	38	6	4	4	21	5	5	4	1	7	5
Edo	41	1	6	3	22	5	3	5	2	10	4
Imo	50	0	3	3	20	4	3	3	1	10	3
Ondo	42	2	3	3	27	4	5	5	1	8	1
Rivers	49	4	3	3	20	4	5	5	2	9	2
Niger Delta	**44**	**4**	**3**	**3**	**20**	**4**	**5**	**5**	**2**	**9**	**2**

Source: National Bureau of Statistics, 2005: Social Statistics in Nigeria

The people of Niger Delta engage mainly in fishing and agriculture but since the growth of the oil industry, agriculture and fishing have become less popular among the young people of the region as they prefer to seek scarce urban employment. Today, majority of those who could not gain white collar jobs either engage in peasant agriculture or take to trading (NDDC 2005, p.20). See Table 1.

Access to reliable electricity supply in the Niger Delta Region is extremely poor. The public utility remains the major source of electricity supply, except in Bayelsa State, which due to its peculiar topography and difficult terrain is yet to be linked to the National Grid. Over 36% of households in the Niger Delta States are without access to electricity from the National Grid. Generally, communities within large settlements have better access to electricity than those in the rural localities. In discharge of their social responsibility, oil companies provide electricity for some communities within their operational areas (NDDC, 2005). The unreliability of electricity supply especially in the rural areas of the region means that there is extensive reliance on expensive back-up generators. Until recently, natives of the Niger Delta enclave especially the youth have protested against gross negligence and underdevelopment coupled with the degradation of their lands by successive Nigerian governments and multinational oil companies. They complain of, among other things, lack of basic social infrastructure including reliable electricity supply.

1.3. Statement of the Problem

The Niger Delta is rich in oil and natural gas which contributes 99 percent of Nigeria's export revenue and 85 percent of government revenues, and approximately 52 percent of gross domestic product (GDP). Despite these resources, the region is marked by deprivation and underdevelopment. The rural natives tired of their plight are particularly embittered. The deplorable condition of the region informed by long period of neglect by successive governments at all levels has been pin-pointed by many researchers as being the chief cause of rising violence and instability in the Niger Delta, particularly since the late 1990s. This study is an addition to several efforts by individuals, organisations and corporate bodies to identify and understand the key factors responsible for the recurrent violent crimes and insecurity in the Niger Delta with a view to entrenching peace in this oil-rich region of Nigeria.

1.4. Research Objectives

The research objectives are as follows:

1. To determine whether power outages constitute a major challenge in the well-being of rural households in the Niger Delta.
2. To ascertain whether power outages constitute a major challenge in the health of rural households in the Niger Delta.
3. To determine whether power outages constitute a major challenge in the economic growth of households in the Niger Delta.
4. To ascertain whether power outages constitute a major challenge in the security of life and property of rural households in the Niger Delta.

5. To determine whether power outages constitute a major challenge in the education of rural households in the Niger Delta.

1.5. Research Questions

From the foregoing research objectives, the following research questions were formulated:
1. Do power outages constitute a major challenge in the well-being of rural households in the Niger Delta?
2. Do power outages constitute a major challenge in the health of rural households in the Niger Delta?
3. Do power outages constitute a major challenge in the economic growth of rural households in the Niger Delta?
4. Do power outages constitute a major challenge in the security of life and property of rural households in the Niger Delta?
5. Do power outages constitute a major challenge in the education of rural households in the Niger Delta?

1.6. Research Hypotheses

In view of the foregoing research questions, the following null hypotheses were formulated:
1. H_O: Power outages do not constitute a major challenge in the well-being of rural households in the Niger Delta.
2. H_O: Power outages do not constitute a major challenge in the health of rural households in the Niger Delta.
3. H_O: Power outages do not constitute a major challenge in the economic growth of rural households in the Niger Delta.
4. H_O: Power outages do not constitute a major challenge in the security of life and property of rural households in the Niger Delta.
5. H_O: Power outages do not constitute a major challenge in the education of rural households in the Niger Delta.

1.7. Literature Review

Africa accounts for 15% of the world's population. Still, it can only boasts of 3% of worldwide annual electricity consumption. The sub-Saharan Africa overall access rate to electricity is nearly 30%, but only 10% for its rural households (UNEP, 2012).

Infrastructure such as electricity is an important input into human development. Adequate and reliable electricity supply improves health care because vaccines and medications can be safely preserved in hospitals and food can be stored at home (Jimenez and Olson 1998).

Gustavsson (2007) revealed in a study about Zambia, the educational benefits resulting from adequate and reliable electricity from solar technology. Though the study did not claim that steady electricity supply resulted in the scoring of higher marks by the school children, but they had at least more time reading and studying their books. Obviously, electricity enhances literacy because students can read and study even when there is no natural light (Barnes 1988; Brodman 1982; Foley 1990; Venkataraman 1990). Uninterruptible access to electricity lowers costs for businesses and encourages investment therefore facilitating economic growth (Reinikka and Svensson 1999).

The use of electricity has health benefits because of lesser cases of eye strain (Cook, n.d). Steady electricity supply improves health care because vaccines and medications can be safely stored in hospitals and food can be preserved at home (Jimenez and Olson 1998). Uninterruptible access to electricity enhances economic growth, increases investment and lowers costs for businesses (Reinikka and Svensson, 1999).

Steady electricity eliminates the need to fetch wood, speeds up cooking time and allows households to conveniently shift activities from daytime into night-time (Dinkelman, 2008). Long and unpredictable power outages affect the quality of lives of rural households as they are forced to suffer from fatigue, irritability and sleepiness in the daytime with the attendant laziness and even a tendency to fall asleep at work or while driving.

However, population increase coupled with underinvestment in the power sector has led to increased power demand without any significant increases in capacity. Lack of equipment maintenance, shortage of fuel and a deficit transmission network are other factors that contribute to the problems plaguing the electricity sector in sub-Saharan Africa. In Nigeria, the factors responsible for electricity shortages include weather, vandalization, water level, ever spiralling electricity demand and improper maintenance culture (Uchendu, 1993).

The Zanzibar blackout grossly diminished household incomes for employees in occupations using electricity. Workers using artificial lighting had work hours reduced by an average of 8%, or 40 minutes per day while those that relied on electricity to power specialized tools suffered even steeper declines, on the order of 35%, or 2.8 fewer hours worked per day (Burlando, 2010). Inadequate and unreliable electricity supply poses a major challenge to economic and social development and hampers human development (Eberhard et al, 2011).

Most residential sectors, especially the poor ones living in rural areas of developing countries are unable to afford reliable modern energy for lack of necessary financial resources. The use of alternative energy such as kerosene and LPG are not attractive because of its short supply and high cost (Abd'razack etal, 2012). The result is that they depend heavily on the use of traditional fuel sources like firewood and charcoal for lighting, cooking and heating activities. In South Africa in the mid-1990s, for instance, over 80% of households

collected wood for household needs and over three-quarters of these were women who on the average spent the equivalent of two working days per week just to gather fuel-wood for their families (Budlender et al, 2002).

According to International Energy Agency (IEA, 2006), about 70% of rural households in sub-Saharan Africa rely on fuel wood, charcoal or kerosene oil. Experts say biomass fuel usage pose serious health risks. In fact, indoor air pollution that results from burning of biomass is responsible for some worrisome health hazards (Muchiri & Gitonga, 2000).

The World Health Organization (WHO) estimated that about 1.5 million premature deaths occur annually due to indoor air pollution from the use of solid fuels including biomass (IEA, 2006). Emitted smokes from biomass fuels have since been pin-pointed as the cause of many respiratory infections and cataracts in some rural areas (UNDP/ESMAP, 2003).

In Kenya, over 70% of its total energy consumption is from wood resources and more than 93% of rural households depend on this source (Abdullah and Markandya, n.d.).

Currently, only 10 percent of rural households and approximately 40 percent of Nigeria's total population have access to electricity. Still, the electricity supply is epileptic owing to gross inadequacy of the energy to meet the ever soaring demand. Electricity shortage in the country is also partly due to vandalism of electrical equipment by hoodlums and lack of investment in the power and gas supply infrastructures needed to capture the natural gas that is currently being flared.

A World Bank report says Nigeria experienced power outages on average for 46 days per year from 2007-2008 and that outages lasted almost six hours on average. Worst still, Some 70 per cent of Nigerians are poor and live on less than US$1.25 per day (Rural Poverty Portal, 2010). Most of this population therefore use traditional biomass, such as wood, charcoal, and waste, to meet household energy needs, such as cooking and heating. Power generation in Nigeria is mainly from thermal plants, which contribute about 60%, and hydro power plants which generate about 30% (Tallapragada, 2009; Adoghe, 2008; Okoro and Chikuni, 2007).

Power outages in households in Nigeria are responsible for many critical issues like unemployment, inflation, lost foodstuffs, crime, increase in households' inconveniences, reduction in leisure, more money spent on purchase of alternative fuels, additional workload especially to women and children and preventable death due to inhalation of gaseous emissions from biomass and electricity generating plants.

2.0. Materials and Methods

The scope of this study is limited to the 1000 randomly selected members of 44 rural households spread across five of the nine states that comprise the Niger Delta region of Nigeria. These are Abia, Cross River, Delta, Edo and Rivers states. It is assumed that responses obtained from the sample respondents would be representative of the opinions of all rural dwellers in the region while the duration of research is between February 2014 and January 2015. The study adopted a cross-sectional survey research design using 1000 randomly selected members of communities mostly affected by incessant power outages for the purpose of questionnaire administration. To ensure reliability of the results from this study, the instrument was pre-tested for validity on five of the rural households. The population of study consists of an estimated 15 million rural dwellers in Niger Delta while the sample size of 1,000 was determined using the Taro Yamani statistical formula assuming a 3% tolerable error. Data collected were analysed using non-parametric simple percentages and presented in tabular form. Stated hypotheses were confirmed using the statistical Chi-square (X^2) technique. A total of 1000 copies of the questionnaire were administered, 80 (8%) were not returned while 920 (92.0%) were retrieved and used for the analysis.

3.0. Results and Discussion

3.1. Distribution of Responses on Research Questions

3.1.1 Question Number 1

Do power outages constitute a major challenge in the well-being of rural households in the Niger Delta? Table 2 shows that a total of 680 i.e. 73.91% of the respondents believed that power outages to a large extent pose a major challenge in the well-being of rural households in the Niger Delta while 240 i.e. 26.09% of the respondents were of the opinion that power outages do not pose a major challenge to the well-being of the people. The researcher therefore conclude that power outages constitute a major challenge to the well-being of rural households in the Niger Delta as evidenced by the large percentage of respondents that answered in the affirmative to the research question. This conclusion is buttressed by the findings made by Jimenez and Olson (1998) to the effect that electricity facilitates the storage of food items as well as powers electrical gadgets in homes thus making life less stressful while adding value to leisure time.

***Table 2**: Response Pattern on whether power outages constitute a major challenge in the well-being of rural households in the Niger Delta*

Responses Provided	Number of Respondents	Percentage of Respondents
Yes	680	73.91%
No	240	26.09%
Total	920	100%

Source: Field Survey, 2014.

3.1.2 Question Number 2

Do power outages constitute a major challenge in the health of rural households in the Niger Delta? Table 3 shows that a total of 720 i.e. 78.26% of the respondents affirmed that power outages contribute a major challenge in the health of rural households in the Niger Delta. Only 200 or 21.74% of the respondents believed that power outages do not pose a major challenge to the health of the people. The researcher therefore conclude that power outage constitutes a major challenge to the health of rural households in the Niger Delta because it does not afford the safe preservation of vaccines and medications in community hospitals and health-centres. This view is strongly supported by Jimenez and Olson (1998).

***Table 3**: Response Pattern on whether power outages constitute a major challenge in the health of rural households in the Niger Delta*

Responses Provided	Number of Respondents	Percentage of Respondents
Yes	720	78.26%
No	200	21.74%
Total	920	100%

Source: Field Survey, 2014.

3.1.3 Question Number 3

Do power outages constitute a major challenge in the economic growth of rural households in the Niger Delta? Table 4 shows that a total of 800 i.e. 86.96% of the respondents affirmed that power outages contribute a major challenge in the economic growth of rural households in the Niger Delta. Only 120 i.e. 13.04% of the respondents believed otherwise. The researcher therefore conclude that power outage constitutes a major challenge to the economic growth of rural households in the Niger Delta. This conclusion is in line with the findings by Eberhard et al, (2011) and Reinikka and Svensson (1999) to the effect that uninterruptible access to electricity enhances economic growth, increases investment and lowers costs for businesses.

***Table 4**: Response Pattern on whether power outages constitute a major challenge in the economic growth of rural households in the Niger Delta*

Responses Provided	Number of Respondents	Percentage of Respondents
Yes	800	86.96%
No	120	13.04%
Total	920	100%

Source: Field Survey, 2014.

3.1.4 Question Number 4

Do power outages constitute a major challenge in the security of life and property of rural households in the Niger Delta? Table 5 shows that a whopping 750 i.e. 81.52% of the respondents are of the opinion that power outages pose a major challenge in the security of life and property of rural households in the Niger Delta. Only 170 i.e. 18.48% of the respondents refuted the claim that power outages pose a major challenge to the security of life and property of the people. The researcher therefore conclude that power outages constitute a major challenge to the security of life and property of rural households in the Niger Delta.

***Table 5**: Response Pattern on whether power outages constitute a major challenge in the security of life and property of rural households in the Niger Delta*

Responses Provided	Number of Respondents	Percentage of Respondents
Yes	750	81.52%
No	170	18.48%
Total	920	100%

Source: Field Survey, 2014.

3.1.5 Question Number 5

Do power outages constitute a major challenge in the education of rural households in the Niger Delta? Table 6 shows that a total of 700 i.e. 76.09% of the respondents are of the opinion that power outages to a large extent pose a major challenge in the education of rural households in the Niger Delta. Only 220 i.e. 23.91% of the respondents believed that power outages do not pose a major challenge to the well-being of the people. The researcher therefore conclude that power outage constitutes a major challenge to the education of rural households in the Niger Delta as it discourages reading by students at night thereby increasing poor performances in examinations and promoting illiteracy among the populace. This is buttressed by Barnes (1988), Brodman (1982), Foley (1990) and Venkataraman (1990) all of which held that electricity promotes literacy because students can read and study when there is no natural light.

***Table 5**: Response Pattern on whether power outages constitute a major challenge in the education of rural households in the Niger Delta*

Responses Provided	Number of Respondents	Percentage of Respondents
Yes	700	76.09%
No	220	23.91%
Total	920	100%

Source: Field Survey, 2014.

3.2 Test of the First Hypothesis

H_O: Power outages do not constitute a major challenge in the well-being of rural households in the Niger Delta.
H_1: Power outages constitute a major challenge in the welfare of rural households in the Niger Delta.
As shown in appendix 1, the calculated value $X^2 = 210.44$ is greater than the tabulated value (3.841) required for 5% level of significance and 1 degree of freedom, the researcher rejects the null hypothesis (H_O) and accepts the alternative. This shows that power outages constitute a major challenge to the well-being of rural households in the Niger Delta. The absence of electricity in a rural household makes the refrigeration of food items and enjoyment of leisure time difficult therefore reducing their living standard.

3.3 Test of the Second Hypothesis

H_O: Power outages do not constitute a major challenge in the health of rural households in the Niger Delta.
H_1: Power outages constitute a major challenge in the health of rural households in the Niger Delta.
As shown in appendix 2, the calculated value $X^2 = 293.92$ is greater than the tabulated value, 3.841 required for 5% level of significance and 1 degree of freedom, the researcher rejects the null hypothesis (H_O) and accepts the alternative. This shows that power outages constitute a major challenge to the health of rural households in the Niger Delta. Clinics and health centres are known to function more effectively when electricity is available than when there is power cut. For instance, vaccines and other health giving substances can be preserved with electric energy so that members of rural households can derive good health-care and live healthily. Besides, the use of alternative sources of energy like biomass impact negatively on the eyes of the rural users.

3.4 Test of the Third Hypothesis

H_O: Power outages do not constitute a major challenge in the economic growth of rural households in the Niger Delta.
H_1: Power outages constitute a major challenge in the economic growth of rural households in the Niger Delta.
As shown in appendix 3, the calculated value $X^2 = 502.61$ is greater than the tabulated value, 3.841 required for 5% level of significance and 1 degree of freedom, the researcher rejects the null hypothesis (H_O) and accepts the alternative. This shows that power outages constitute a major challenge to the economic growth of rural households in the Niger Delta. Power outages shorten the business hours of those living in rural communities in the Niger Delta and therefore reduces their income and means of livelihood.

3.5 Test of the Fourth Hypothesis

H_O: Power outages do not constitute a major challenge in the security of rural households in the Niger Delta.
H_1: Power outages constitute a major challenge in the security of life and property of rural households in the Niger Delta.
As shown in appendix 4, the calculated value $X^2 = 365.55$ is greater than the tabulated value, 3.841 required for 5% level of significance and 1 degree of freedom, the researcher rejects the null hypothesis (H_O) and accepts the alternative. This shows that power outages constitute a major challenge to the security of life and property of rural households in the Niger Delta. Power outages encourage the perpetration of all sorts of criminal activities. People choose to do evil in darkness. The absence of electricity makes it possible and easy for thieves and rapists to prey on their victims.

3.6 Test of the Fifth Hypothesis

H_O: Power outages do not constitute a major challenge in the education of rural households in the Niger Delta.
H_1: Power outages constitute a major challenge in the education of rural households in the Niger Delta.
As shown in appendix 5, the calculated value $X^2 = 250.44$ is greater than the tabulated value, 3.841 required for 5% level of significance and 1 degree of freedom, the researcher rejects the null hypothesis (H_O) and accepts the alternative. This shows that power outages constitute a major challenge to the education of rural households in the Niger Delta.

4.0 Conclusion and Recommendations

The paper discussed the consequences of power outages on the social and economic lives of rural households in the Niger Delta region of Nigeria. It assumed that government can improve the outlook of rural dwellers and minimise the recurring violent protests from the oil-rich region by addressing the issue of infrastructure deficit in the area. The five findings of this investigation are as follows:

- Power outages constitute a major challenge in the well-being of rural households in the Niger Delta.
- Power outages constitute a major challenge in the health of rural households in the Niger Delta.
- Power outages constitute a major challenge in the economic growth of rural households in the Niger Delta.
- Power outages constitute a major challenge in the security of life and property of rural households in the Niger Delta.
- Power outages constitute a major challenge in the education of rural households in the Niger Delta.

In view of the foregoing findings of this paper, therefore, the researcher suggests as follows:

1. Government should encourage the use of alternative sources of energy such as gas for cooking and heating in order to reduce the demand for electricity. This could be achieved if government partners with the private sector to subsidise the product.
2. Government should engage the Private sector operators in joint partnerships in order to stimulate and sustain necessary investment in and make the power sector more efficient.
3. With the abundance of oil and gas resources and the renewable energies (solar and wind) in the Niger Delta, off-grid electrification project, if properly harnessed, is a likely solution to the perennial problem of power outages in the region.
4. Government should implement the on-going power sector reforms to its logical conclusion so that there can be stable electricity supply even in the rural areas to facilitate and encourage sustainable economic production and productivity among the rural populace.
5. Government should pay due attention to rural households especially those in the Niger Delta region in order to eradicate such violent crimes as youth militancy.
6. Further research is necessary in adopting affordable and health-friendly alternative sources of energy that would be dedicated to the rural communities in the region.

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Competing Interests

The author declares that no competing interests exist.

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Appendix 1

Computation of calculated X^2 for the First Hypothesis

From table 2, we can proceed as follows to obtain X^2 for observed frequency, O = 680 and 240. First, we obtain the expected frequency, E

Using X^2,

$$E = \Sigma \frac{920}{2} = 460$$

We can now construct the table below showing the calculated value of X^2:

O	E	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
680	460	220	48,400	105.22
240	460	-220	48,400	105.22
			Total	**210.44**

$$X^2 = \Sigma \frac{(O-E)^2}{E}$$

$= 105.22 + 105.22$

$= 210.44$

$X^2 = 210.44$

Appendix 2

Computation of Calculated X^2 for the Second Hypothesis

From table 3, we can proceed as follows to obtain X^2 for observed frequency, O = 720 and 200. First, we obtain the expected frequency, E

Using X^2,

$$E = \Sigma \frac{920}{2} = 460$$

We can now construct the table below showing the calculated value of X^2:

O	E	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
720	460	260	67,600	146.96
200	460	-260	67,600	146.96
			Total	**293.92**

$$X^2 = \Sigma \frac{(O-E)^2}{E}$$

$= 146.96 + 146.96$

$= 293.92$

$X^2 = 293.92$

Appendix 3
Computation of Calculated X^2 for the Third Hypothesis
From table 4, we can proceed as follows to obtain X^2 for observed frequency, O = 800 and 120. First, we obtain the expected frequency, E
Using X^2,

$$E = \Sigma \frac{920}{2} = 460$$

We can now construct the table below showing the calculated value of X^2:

O	E	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
800	460	340	115,600	251.30
120	460	-340	115,600	251.30
			Total	**502.61**

$$X^2 = \Sigma \frac{(O-E)^2}{E}$$

$= 251.30 + 251.30$

$= 502.61$

$X^2 = 502.61$

Appendix 4
Computation of Calculated X^2 for the Fourth Hypothesis
From table 5, we can proceed as follows to obtain X^2 for observed frequency, O = 750 and 170. First, we obtain the expected frequency, E
Using X^2,

$$E = \Sigma \frac{920}{2} = 460$$

We can now construct the table below showing the calculated value of X^2:

O	E	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
750	460	290	84,100	182.83
170	460	-290	84,100	182.83
			Total	**365.66**

$$X^2 = \Sigma \frac{(O-E)^2}{E}$$

$= 182.83 + 182.83$

$= 365.66$

$X^2 = 365.66$

Appendix 5
Computation of Calculated X^2 for the Fifth Hypothesis
From table 6, we can proceed as follows to obtain X^2 for observed frequency, O = 700 and 220. First, we obtain the expected frequency, E
Using X^2,

$$E = \Sigma \frac{920}{2} = 460$$

We can now construct the table below showing the calculated value of X^2:

O	E	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
700	460	240	57,600	125.22
220	460	-240	57,600	125.22
			Total	**250.44**

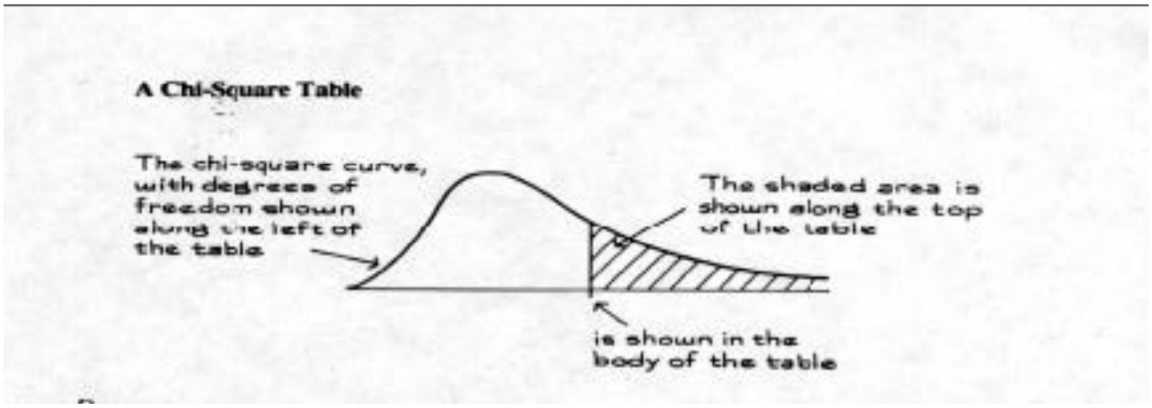
$$X^2 = \Sigma \frac{(O-E)^2}{E}$$
$$= 125.22 + 125.22$$
$$= 250.44$$

$X^2 = 250.44$

Appendix 6
The Chi-square Table

Degrees of Freedom	99%	95%	90%	70%	50%	30%	10%	5%	1%
1	0.00016	0.0039	0.016	0.15	0.46	1.07	2.71	3.84	6.64
2	0.020	0.10	0.21	0.71	1.39	2.41	4.60	5.99	9.21
3	0.12	0.35	0.58	1.42	2.37	3.67	6.25	7.82	11.34
4	0.30	0.71	1.06	2.20	3.36	4.88	7.78	9.49	13.28
5	0.55	1.14	1.61	3.00	4.35	6.06	9.24	11.07	15.09
6	0.87	1.64	2.20	3.83	5.35	7.23	10.65	12.59	16.81
7	1.24	2.17	2.83	4.67	6.35	8.38	12.02	14.07	18.48
8	1.65	2.73	3.49	5.53	7.34	9.52	13.36	15.51	20.09
9	2.09	3.33	4.17	6.39	8.34	10.66	14.68	16.92	21.67
10	2.56	3.94	4.86	7.27	9.34	11.78	15.99	18.31	23.21
11	3.05	4.58	5.58	8.15	10.34	12.90	17.28	19.68	24.73
12	3.57	5.23	6.30	9.03	11.34	14.01	18.55	21.03	26.22
13	4.11	5.89	7.04	9.93	12.34	15.12	19.81	22.36	27.69
14	4.66	6.57	7.79	10.82	12.34	16.22	21.06	23.69	29.14
15	5.23	7.26	8.55	11.72	14.34	17.32	22.31	25.00	30.58
16	5.81	7.96	9.31	12.62	15.34	18.42	23.54	26.30	32.00
17	6.41	8.67	10.09	13.53	16.34	19.51	24.77	27.59	33.41
18	7.00	9.39	10.87	14.44	17.34	20.60	25.99	28.87	34.81
19	7.63	10.12	11.65	15.35	18.34	21.69	27.20	30.14	36.19
20	8.26	10.85	12.44	16.27	19.34	22.78	28.41	31.41	37.57

Source: Adapted from p.112 of Sir R.A. Fisher, *Statistical Methods fro Research Workers* (Edinburgh: Oliver and Boyd, 1958).


A Chi-Square Table
The chi-square curve, with degrees of freedom shown along the left of the table
The shaded area is shown along the top of the table
is shown in the body of the table

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