



## Induced Abortion Trends for Senior Women ( $\geq 35$ Years Old) in New Zealand Between 2000--2019

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### Abstract

Senior women ( $\geq 35$ ) pregnancies and linked induced abortions always indicate a serious women's health issue. Any woman age  $\geq 35$  years old is considered herein as a senior. The induced abortions trends of senior women in New Zealand for the period 2000 to 2019 is determined in the current article. Senior women are grouped into three age groups such as 35 - 39, 40 - 44 and  $\geq 45$  years old. For each age group, mean and variance trend equations are examined, and for the age group 35 - 39, both the mean and variance trends equations are derived herein, and for the rest two groups only the mean trend equations are derived as the variance is constant for these two groups. For the above three age groups, the mean and variance trend is a non-linear polynomial, and the mean trend is of five, three, and first degree, while the variance trend is of fourth, zero, zero degree polynomial in time, respectively. The trend curve for the age  $\geq 45$  years old is strictly increasing, while trend curve for the age groups (35 - 39), or (40 - 44) is initially increasing up to 2006, or 2005, and after that they are declining up to 2014, or 2015, and finally they are increasing over the time. The derived trend models can forecast the induced abortion numbers in future. Many social educational plans related family planning are highly necessary at school/college levels to impart the adverse effects knowledge of induced abortions to women health, that may reduce the senior women's induced abortions. Some extra efforts are requisite to impart the required education on effective contraception use and family planning.

**Keywords:** Family Planning; Health Issue; Joint Generalized Linear Models (JGLMs); Induced Abortion; Non-Constant Variance; Senior Adults; Trends

### Introduction

Senior women pregnancies and linked induced abortions are always connected with a serious public health issue [1,2]. In some countries such as USA, Sweden, New Zealand, Australia, a pre-viable fetus abortion is legal, while it is illegal in several countries over the world. For USA also, there are several state-related limitations such as gestational age restrictions, mandatory waiting periods exist, and there are approximately 50% unintended

pregnancies, while 40% of the unintended pregnancies end in induced abortion, about 90% of these procedures are cleaned during the 1<sup>st</sup> trimester [3,4]. Commonly, it is safe with no complications for the countries with legal abortion, while it is highly risky for women's health for the countries with illegal abortion [3-5].

Induced abortions are greatly linked with major women's health issues, which is a common gynecological process. Despite highly advanced abortion procedures, there are some known risks

and adverse effects, which should be considered in women's health issues. The induced abortion completion process can be examined easily by watching the removal of uterine contents through ultrasonography, which is used during the process. Throughout the world, approximately, 13% of maternal deaths are secondary due to induced abortions, while majority of these deaths happen in the countries with illegal abortion [5-7]. Major complications linked with induced abortions include high bleeding, an infection in the upper genital tract, sever pain, an incomplete abortion that causes salpingitis, endometritis, parametritis and oophoritis [6-9].

Senior women's induced abortions trends are studied very little in the earlier articles [1,2,10]. In women's health studies, generally, induced abortions trends are not examined using mathematical models. The word "Trend" is linked to a data set for a long time period that is termed as time series data. Trend is usually defined as the persevering and gradual movement for a long time series period. Therefore, the long term variation of a time series data for smooth upward increase, or downward decrease is termed as trend [11,12]. In practice, the trend problem derivation is really a statistical statement, and we have by no means turned the problem to a mathematical form, nor have we done away with the necessary for requisite verifications of the characteristics of the original data. The trends of induced abortions are very little studied using statistical modeling [2,10].

### Aim of the Study

The current article makes an attempt to derive the induced abortions trend equations for the senior women ≥ 35 years old adopting statistical approaches of joint generalized linear models (JGLMs), which are rarely applied in the study of induced abortions literature.

## Materials and Statistical Methods

### Materials

The present paper considers induced abortions data for senior women (≥ 35 years old) of New Zealand from the year 2000 to 2019. The data description and their values can be found in the website link source: <https://catalogue.data.govt.nz/dataset/abortion-statistics> It includes induced abortions information for women ≥ 11years old with three columns that describe the data collection year, women's age, induced abortions numbers. For immediate use in the article, the data set for three age groups (35 - 39), (40 - 44) and ≥ 45 years old are given in table 4.

### Statistical methods

The present study considers the senior women (≥ 35 years old) induced abortions trends of New Zealand from the year 2000 to 2019 based on the data set is given in table 4. It is identified herein that the random response abortion numbers over time for the three age groups (35 - 39), (40 - 44) and ≥ 45 is positive, homogeneous (or heterogeneous), and non-normally distributed. The data set is analyzed herein adopting the gamma distribution under JGLMs and GLMs which are neatly given in the book by Lee, Nelder and Pawitan [13] and by Das [14]. For ready reference, the gamma JGLMs is shortly reported herein.

**Gamma JGLMs:** The positive random variable herein is the number of induced abortions= $Y_i$ 's (say), with mean= $E(Y_i) = \mu_i$  (say), unequal variance ( $\sigma_i^2$ ) with  $\text{Var}(Y_i) = \sigma_i^2 \mu_i^2 = \sigma_i^2 V(\mu_i)$  say, where  $V(\cdot)$  reveals the dispersion function. It is noted herein that the variance has two elements such as  $\sigma_i^2$  (free of  $\mu_i$ 's) and  $V(\mu_i)$  (depending on  $\mu_i$ 's). The dispersion function  $V(\cdot)$  presents the GLM family distributions. For instance, if  $V(\mu) = \mu$ , it is Poisson, normal if  $V(\mu) = 1$ , and gamma if  $V(\mu) = \mu^2$  etc. Mean and dispersion models of gamma JGLMs are as follows:

$$\eta_i = g(\mu_i) = x_i' \beta \text{ and } \varepsilon_i = h(\sigma_i^2) = w_i' \gamma,$$

Where  $g(\cdot)$  and  $h(\cdot)$  are the GLM link functions for the mean and dispersion linear predictors respectively, and  $x_i'$ ,  $w_i'$  are the independent explanatory variables vectors linked with the mean and dispersion parameters respectively. Maximum likelihood (ML) method is adopted to estimate mean parameters, and the restricted ML (REML) method is applied to estimate dispersion parameters, which are elaborately given in the book by Lee, Nelder and Pawitan [13].

## Statistical Analysis and Results

### Statistical analysis

The response senior women's induced abortion numbers of New Zealand from the year 2000 to 2019 is modelled herein using JGLMs (or GLMs) with the gamma distribution taking the transformed time  $t$  (=Year-2009) as the independent variable, sine the response variable induced abortion numbers is positive heteroscedastic (or homoscedastic). Final model is selected based on the lowest Akaike information criterion (AIC) value (within each class) that reduces both the squared error loss and predicted additive errors [15; p. 203-204]. For the age group (35 - 39), the response se-

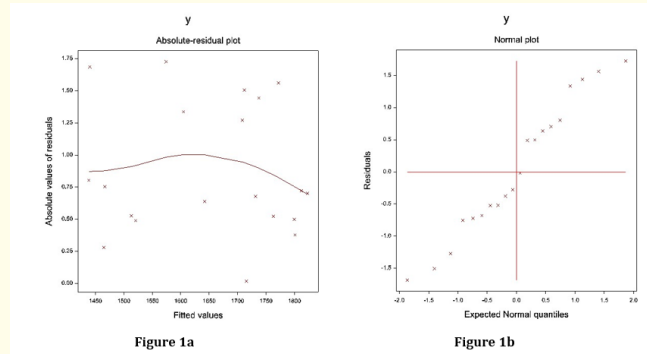
nior women’s induced abortion numbers is heteroscedastic, while it is homoscedastic for the age groups (40 - 44) and ≥ 45 years old. For the age group (35 - 39), in the mean model  $t$ ,  $t^2$ ,  $t^3$ ,  $t^4$  and  $t^5$  are included as all of them are significant, while in the variance model only  $t^2$  and  $t^4$  are significant, but all  $t$ ,  $t^2$ ,  $t^3$  and  $t^4$  are included due to the functional marginality rule (i.e. if a higher degree (i.e.  $t^4$ ) term is significant, then all its lower degree should be included in the model) by McCullagh and Nelder [16]. The gamma JGLM fit analysis outcomes for the senior women’s induced abortion numbers for age (35 - 39) are given in table 1.

Model	Covariate	Estimate	Standard error	t-value	P-Value
Mean	Constant	7.441	0.0074570	997.800	< 0.0001
	$t^1$	-0.03867	0.0037510	-10.310	< 0.0001
	$t^2$	-0.003320	0.0006887	-4.820	< 0.0001
	$t^3$	0.0007823	0.0001638	4.776	< 0.0001
	$t^4$	0.00004228	0.0000079	5.287	< 0.0001
	$t^5$	-0.000004751	0.0000015	-3.159	0.0016
Dispersion	Constant	-8.996421	0.7088789	-12.691	< 0.0001
	$t^1$	-0.290281	0.1851915	-1.567	0.1394
	$t^2$	0.130412	0.0523060	2.493	0.0258
	$t^3$	0.007087	0.0037702	1.880	0.0811
	$t^4$	-0.001638	0.0007268	-2.253	0.0408
AIC		204.3353			

**Table 1:** Gamma fitted JGLMs for the induced abortions data for the age group (35 - 39) years old.

The derived senior women’s induced abortions gamma JGLMs fitted model for the age group (35 - 39) in table 1 is a data obtained model that is selected based on model fitting checking plots in figure 1. In figure 1a, JGLMs gamma fitted absolute residuals for the senior women’s induced abortions for age (35-39) are plotted against the fitted value, which is nearly a flat straight line, concluding that the variance is constant with the running means. Figure 1b shows normal probability plot of the JGLMs gamma fitted induced abortions mean model for age (35 - 39) (Table 1), which does not show any lack of fit. Both these plots in figure 1 show that the derived JGLMs gamma fitted induced abortions trend model for senior women age (35 - 39) group is almost correct.

Similarly, for the age group (40 - 44), the response senior women’s induced abortion numbers is homoscedastic that is modelled



**Figure 1:** For the JGLMs gamma fitted induced abortions models for age (35 - 39) (Table 1), the (a) absolute residuals plot against the fitted values, and (b) the mean model normal probability plot.

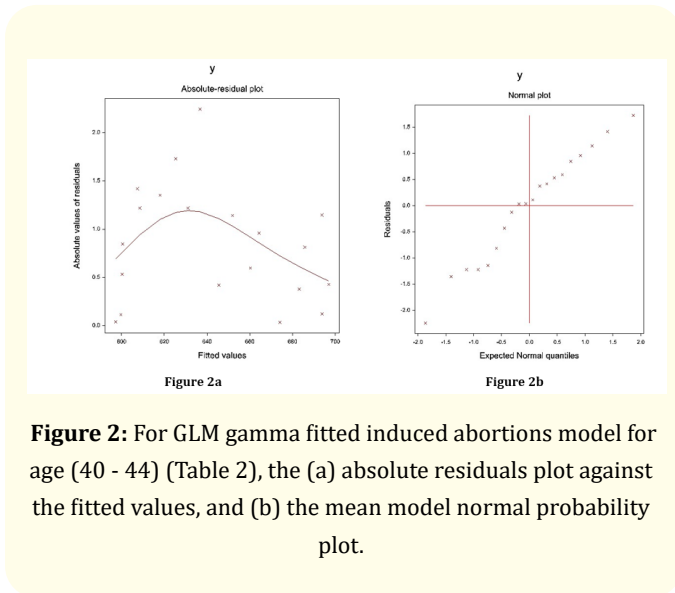
by adopting gamma GLM model, and the summarized results are presented in table 2. For the age group (40 - 44), in the mean model  $t$ ,  $t^2$  and  $t^3$  are included as they are all significant.

Model	Covariate	Estimate	Standard error	t-value	P-Value
Mean	Constant	6.4927201	0.0123900	523.953	< 0.0001
	$t^1$	-0.0219757	0.0035560	-6.179	< 0.0001
	$t^2$	-0.0009212	0.0002886	-3.192	0.0014
	$t^3$	0.0002991	0.0000551	5.424	< 0.0001
Dispersion	Constant	-6.607	0.3535000	-18.69	< 0.0001
AIC		187.2467			

**Table 2:** Induced abortions data GLM gamma fitted results for the age group (40 - 44) years old.

The derived senior women’s induced abortions GLM gamma fitted model for age (40 - 44) in table 2 is tested by model fitting diagnostic plots in figure 2. In figure 2a, absolute residuals for the GLM gamma fitted induced abortions for age (40 - 44) are plotted against the fitted value, which is nearly a flat straight line, except the two tails, indicating that the variance is constant with the running means. Note that both tails are little decreasing as some small-

er absolute residuals are located at the two boundaries. Figure 2b shows normal probability plot of the GLM gamma fitted induced abortions mean model for age (40 - 44) (Table 2), which does not indicate any lack of fit. Both these plots in figure 2 show that the derived GLM gamma fitted trend model of the induced abortions for age (40 - 44) is almost correct.



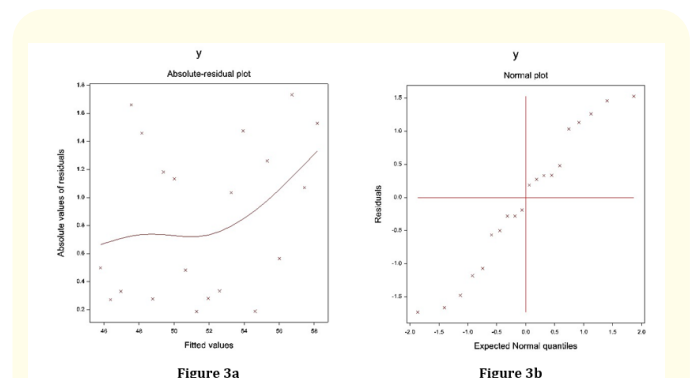
Similarly, for age ≥ 45 years old, the response senior women’s induced abortion numbers is homoscedastic, which is analyzed by adopting gamma GLM, and the summary outcomes are shown in table 3. For age ≥ 45 years old, in the mean model only t is included as it is only significant.

Model	Covariate	Estimate	Standard error	t-value	P-Value
Mean	Constant	3.93752	0.030801	127.838	< 0.0001
	t <sup>1</sup>	0.01259	0.005322	2.366	0.0180
Disper-sion	Constant	-3.96	0.332800	-11.90	< 0.0001
AIC		137.0885			

**Table 3:** Induced abortions data GLM gamma fitted results for the age group (≥ 45) years old.

The derived senior women’s induced abortions for age ≥ 45 years old, GLM gamma fitted model in table 3 is tested by model fit-

ting diagnostic plots in figure 3. In figure 3a, absolute residuals for the GLM gamma fitted of induced abortions for senior women age ≥ 45 years old are plotted against the fitted value, which is nearly a flat straight line, except the right tail, interpreting that the variance is constant with the running means. The right tail is little increasing as a larger absolute residual is located at the right boundary. Figure 3b shows normal probability plot of the GLM gamma fitted induced abortions mean model for senior women age ≥ 45 years old (Table 3), which does not present any lack of fit. Both these plots in figure 3 show that derived GLM gamma fitted trend model of the induced abortions for senior women age ≥ 45 years old is almost correct.



**Analysis results**

Table 1 shows the summarized JGLMs analysis outcomes of senior women’s induced abortions trend for the age group (35 - 39) under JGLMs gamma fit. Gamma fitted mean model shows that the mean response of the senior women’s induced abortion numbers is a fifth degree function of time “t”. Note that time “t” is the transformed time, where t = (Period - 2009) (Shown in table 4). In the mean model, t (P < 0.0001), t<sup>2</sup> (P < 0.0001), t<sup>3</sup> (P < 0.0001), t<sup>4</sup> (P < 0.0001) and t<sup>5</sup> (P = 0.0016) are significant. In the variance model, t<sup>2</sup> (P = 0.0258) and t<sup>4</sup> (P = 0.0408) are significant, while t (P = 0.1394) and t<sup>3</sup> (P = 0.0811) are partially significant and they are included in the model due to the functional marginality rule by by McCullagh and Nelder [16].

JGLM gamma fitted senior women induced abortions for age (35 - 39) mean ( $\hat{\mu}(35 - 39)$ ) model (Table 1) is  $\hat{\mu}(35-39)$

=exp(7.441 - 0.03867 t -- 0.003320 t<sup>2</sup> + 0.0007823 t<sup>3</sup> + 0.00004228 t<sup>4</sup> -- 0.000004751 t<sup>5</sup>) and the fitted mean trend values are given in table 4.

exp(6.4927201 - 0.0219757 t --0.0009212 t<sup>2</sup> + 0.0002991 t<sup>3</sup>), and the fitted mean trend values are given in table 4.

The gamma fitted senior women induced abortions for age (35-39) dispersion ( $\hat{\sigma}^2$  (35-39)) model is

GLM gamma fitted senior women’s induced abortions for age (40 - 44) dispersion ( $\hat{\sigma}^2$  (40-44)) is  $\hat{\sigma}^2$  (40-44) = exp(--6.607).

$$\hat{\sigma}^2$$
 (35-39) = exp(-8.996421 -- 0.290281 t + 0.130412 t<sup>2</sup> + 0.007087 t<sup>3</sup>-- 0.001638 t<sup>4</sup>).

Table 3 presents the summarized GLM gamma fitted outcomes of senior women’s induced abortions trend for the age ≥ 45 years old. GLM gamma fitted mean model shows that the mean response of induced abortion numbers for the senior women age ≥ 45 years old is a first degree function of time “t”. In the mean model, t (P = 0.0180) is only significant.

Table 2 shows the summarized gamma GLM analysis outcomes of senior women’s induced abortions trend for the age group (40 - 44). Gamma GLM fitted mean model shows that the mean response of induced abortion numbers for (40 - 44) is a third degree function of time “t”. In the mean model, t (P < 0.0001), t<sup>2</sup> (P = 0.0014) and t<sup>3</sup> (P < 0.0001) are all significant.

GLM gamma fitted senior women’s induced abortions for age ≥ 45 mean ( $\hat{\mu}$  (≥ 45)) model (Table 2) is  $\hat{\mu}$  (≥ 45) = exp(3.93752 + 0.01259 t), and the fitted mean trend values are given in table 4.

GLM gamma fitted senior women’s induced abortions for age (40 - 44) mean ( $\hat{\mu}$  (40 - 44)) model (Table 2) is  $\hat{\mu}$  (40 - 44) =

GLM gamma fitted senior women’s induced abortions for age ≥45 dispersion ( $\hat{\sigma}^2$  (≥45)) is  $\hat{\sigma}^2$  (≥45) = exp(--3.96).

Year	t <sup>1</sup>	Abortion no. age (35 - 39)	Fitted abor. no. age (35 - 39)	Abor. no. age (40 - 44)	Fitted abor. no age (40 - 44)	Abor. no. age (≥ 45)	Fitted abor. no. age (≥ 45)
2000	-9	1823	1822.1	613	600.5	43	45.8
2001	-8	1730	1748.0	593	636.8	48	46.4
2002	-7	1715	1740.7	686	664.4	49	47.0
2003	-6	1846	1765.6	692	683.2	38	47.6
2004	-5	1916	1798.7	721	693.8	58	48.2
2005	-4	1773	1822.9	687	697.0	47	48.8
2006	-3	1777	1827.3	691	693.9	42	49.4
2007	-2	1814	1807.4	667	685.8	58	50.0
2008	-1	1754	1764.5	675	674.2	54	50.6
2009	0	1692	1704.5	674	660.3	50	51.3
2010	1	1649	1635.7	655	645.6	50	51.9
2011	2	1593	1567.4	605	631.1	55	52.6
2012	3	1506	1507.9	590	618.1	61	53.3
2013	4	1451	1464.4	637	607.4	44	53.9
2014	5	1384	1442.3	611	600.2	56	54.6
2015	6	1483	1445.6	598	597.2	65	55.3
2016	7	1443	1476.8	602	599.6	52	56.0
2017	8	1562	1536.4	584	608.6	45	56.7
2018	9	1679	1621.7	660	625.4	50	57.4
2019	10	1707	1723.8	634	651.9	70	58.2

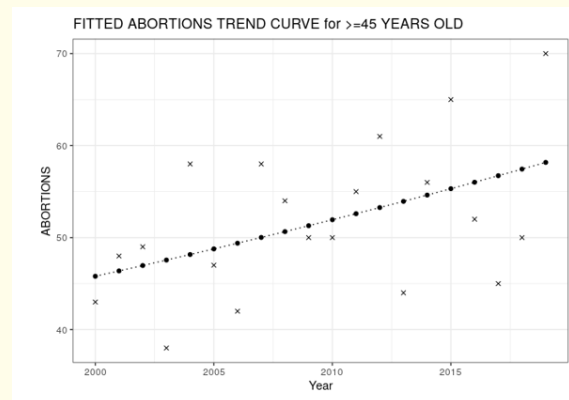
**Table 4:** Original and fitted induced abortions data for the age groups (35 - 39), (40 - 44), (≥ 45).

**Discussions and Conclusion**

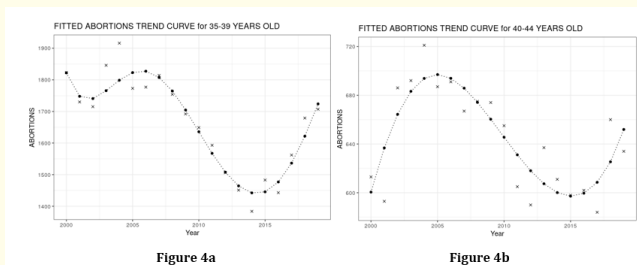
The article has developed senior women’s (≥35 years old) induced abortions trends of New Zealand from the year 2000 to 2019 adopting statistical JGLMs/ GLMs under the gamma distribution. Commonly, trend equations are obtained assuming variance is constant [11,12]. When the variance is unequal, it is important to develop both the mean and variance trends jointly, which are rarely studied in time series analysis. Best of our knowledge, senior women’s induced abortions trends are rarely studied in the women’s health literature adopting statistical methods [2,10]. Here the response senior women’s induced abortions variance is unequal for age (35 - 39), while it is constant for the age groups (40 - 44) and ≥ 45 years old, and they should be analyzed by using JGLMs/GLMs. The current article has studied first time of senior women’s induced abortion trends adopting advanced statistical models. Moreover, final models are accepted with stable estimates, as their standard errors are very small (Table 1-3), and based on minimum AIC value, graphical diagnosis (Figure 1-3). The research should have a higher confidence on the present derived findings.

From figure 4a and 4b and table 4, it is seen that the senior women’s induced abortions trend for age (35 - 39), or (40 - 44) of New Zealand from the year 2000 - 2019 is initially increasing from 2000 to 2006, or 2000 to 2005, and after that it is declining up to 2014, or 2015, and after that both are increasing. From figure 4a and 4b (also from table 4), it is seen that original and fitted values are very close to each other. The current findings imply that the impacts of family planning education and contraception use are not satisfactorily effective for the senior women (35 - 44) in New Zealand.

From figure 5 and table 4, it is seen that the senior women’s induced abortions trend for ≥ 45 years old of New Zealand from the year 2000 to 2019 is strictly increasing from 2000 to 2019. The present findings imply that the impacts of contraception use and family planning education are not well effective for the senior women for ≥45 years old in New Zealand. This situation is completely different from the senior women age group (35 - 44). Further studies are required to locate the casual factors linked to the increase of induced abortions for the senior women ≥ 35 years old in New Zealand. Similar situations, or many more adverse situations may be found in many developing, or under developing countries. Some research studies are to be performed for such countries.



**Figure 5:** Scattered plot of the original observations, fitted values and the smooth fitted mean trend curves for the age group ≥ 45 years old.



**Figure 4:** Scattered plot of the original observations, fitted values and the smooth fitted mean trend curves for the age group (a) (35 - 39) and (b) (40 - 44).

There is no similar study for the senior women’s induced abortions trends of New Zealand, so the current outcomes cannot be compared with the earlier studies. The current derived outcomes and models are clearly tested by figure 1-5. Here it is found that the fitted values are very close to the original data. The preset outcomes will help the researchers and the Government for interpreting the future senior women’s induced abortions in New Zealand. Based on the interpretation from the current paper, the Government can take requisite actions. The family planning education is to be continued in New Zealand, and other developing, or under developing countries.



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