**Statistical Analysis of Monkeypox Cases for Canada, USA, UK and Germany**

**By: Ivy Osei and Woldegebriel Assefa Woldegerima**

**Abstract**

Various approaches have been used to model and predict infectious disease outbreaks. Our study used statistical modelling to analyze weekly monkeypox cases for Canada, USA, UK and Germany. We used Poisson time series regression to account for the skewedness of the underlying distributions of monkeypox cases. In comparison, linear regression failed to provide us with a good forecast since a jump in each graph indicated that the curve follows a logistic function. For the studied countries, the Poisson time series regression model demonstrated good surveillance of monkeypox cases and underlying trends in the data. Epidemiologists can conduct accurate and timely surveillance of all organisms using log-linear regression models that account for seasonality and trends. Infectious disease data are better modeled using Poisson time series regression than linear regression. As a result of our Poisson time series regression models, our study concludes that the monkeypox virus has reached an end in Canada, the USA, the UK and Germany until a resurgence occurs.

**Introduction**

Monkeypox is a disease caused by the monkeypox virus that can be transmitted from animals to humans and among humans (World Health Organization, 2023). The monkeypox virus belongs to the genus orthopoxyvirus of the Poxviridae family (*Factsheet for Health Professionals on Mpox (Monkeypox)*, n.d.). Other members in the orthopoxyvirus genus are the vaccinia virus, variola virus, cowpox virus and several other animal pathogen viruses. The monkeypox virus is an enveloped, double-stranded DNA virus (*Factsheet for Health Professionals on Mpox (Monkeypox)*, n.d.).

The virus was first detected in monkeys in a laboratory in 1958 and the first case of animal-to-human transmission occurred in 1970 in a nine-month-old child from the Democratic Republic of Congo (Lulli et al., 2022). Human-to-human transmission occurs directly, indirectly, and vertically (Goyal et al., 2022). Symptoms include fever and headaches for the first 8 to 12 days after exposure followed by a rash all over the whole body, 8 to 14 days after exposure (Reynolds & Damon, 2012).

A May 2022 monkeypox outbreak differed from previous outbreaks in that it is mostly occurred in non-endemic countries rather than West and Central Africa, where it has historically been endemic (World Health Organization, 2022). Additionally, it disproportionally affects men sex within the men community as one of its primary risk factors and the transmission is primarily through sexual networks, although this is not the only method (Dou et al., 2023). Several authors have used mathematical, statistical and machine learning models to model and predict monkeypox cases. In this project, we will use some statistical modelling to analyze data for the number of monkeypox cases for different countries (Canada, USA, UK, Germany) using data obtained from Our World in Data website. In the following, we summarized major methods used for infectious disease modelling and prediction to pave the way for our own approach.

Epidemiological surveillance is used to analyze infectious diseases of public health concern (Farrington et al., 1996). One method of early detection of infectious diseases is voluntary reporting of surveillance data, but this is ineffective due to bias and delays (Farrington et al., 1996). Often, errors cannot be corrected due to the speed at which reports must be processed. As a result, various methods of automated statistical analysis are more appropriate for processing large amounts of data in a timely manner (Farrington et al., 1996).

Most statistical methods for modelling of infectious disease data analyze retrospective case series (Farrington et al., 1996). Examples are regression techniques that retrospectively analyze the clustering of health events according to Poisson or normal errors. Furthermore, other methods utilize the clustering pattern of seasonality to detect temporal patterns in epidemiology (Farrington et al., 1996).

In prospective analysis of infectious disease data, detecting clustering of events in recent time intervals is of interest (Farrington et al., 1996). A method called cumulative sum statistics originally used in industrial settings has been used in the early detection of influenza epidemics (Farrington et al., 1996). (Stroup *et. al*., 1989), developed a system where aberrations in reports of infectious diseases are flagged based on a threshold determined by parametric methods of normal distribution. Time series analysis and exponential smoothing of the time series have also been used to detect outbreaks (Farrington et al., 1996).

To detect outbreaks in England and Wales, the Communicable Disease Surveillance Centre (CDSC) uses weekly reports of infectious diseases (Farrington et al., 1996). The number of strains of organisms reported every week varies from 200 to 350, including tuberculosis and salmonella. To analyze and predict outbreaks of neglected organisms, an automated system is required since manual scanning of current and past outbreaks is not sufficient (Farrington et al., 1996).

An infectious disease surveillance program aims to detect unusually high incidences of events compared to seasonal patterns or secular trends (Farrington et al., 1996). To ensure early detection and preparedness, timeliness and sensitivity are essential. However, disease incidence should not be overestimated to ensure the system’s reliability (Farrington et al., 1996).

Ideally, the data for the week should be collected during the week and analyzed over the weekend (Farrington et al., 1996). At the time of publication in 1996, Farrington *et al*., believed that time series analysis is not appropriate since it takes time to model an organism with this method. In that study, the authors proposed that "a single robust algorithm" should be employed in the surveillance of all organisms. This algorithm should be able to handle different "organism frequencies, seasonal patterns, underlying trends, and extraneous noise in the data...without sacrificing sensitivity and specificity" (Farrington et al., 1996). This method is the log-linear regression model that is adjusted for overdispersion. Moreover, the current week's observed count will be flagged if it exceeds the threshold, which is the expected value for the current week based on previous data (Farrington et al., 1996).

Using linear regression and Poisson time series regression (ISEE Global Education Channel, 2018), which is derived from log-linear regression, we model weekly monkeypox cases for Canada, the United States, the United Kingdom, and Germany.

**Methods**

**Data Sources**

In this study, Our World in Data website was used to obtain data on monkeypox cases from 01/06/2022 to 17/07/2023 for Canada and the USA. Data from 07/05/2022 and 20/05/2022 to 17/07/2023 were obtained for the UK and Germany, respectively (Edouard Mathieu et al., 2022).

**Data Analysis**

Weekly cumulative monkeypox cases and smoothed 7-day rolling average of the 2022 outbreak were obtained from Our World in Data Website for Canada, the USA, Germany, and the UK (Edouard Mathieu, 2022). Analysis of the data was performed using the Excel Analysis Toolpak in Microsoft Excel (Sergev et al., 2022). Moreover, we developed a time series Poisson regression model for Canada and the USA using a 7-day rolling average of monkeypox cases from June 2022 to July 2023 and for the UK and Germany from May 2022 to July 2023. Seasonality was considered when modeling the case data using spline functions. To control for season and time trends over the two-year period, we used a spline with eight knots. Forecasting cases beyond the original data frame using the predict.glm function and other methods resulted in errors. To forecast cases, we would have had to train the data on the dataset before validating the cases via forecasting using machine learning.

**Statistical Analysis**

**Table 1. Descriptive statistics of weekly monkeypox cases**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Mean** | **St. Dev** | **Minimum** | **Maximum** |
| **Weekly number of monkeypox cases in Canada** | 3.63 | 6.11 | 0 | 23.43 |
| **Weekly number of monkeypox cases in USA** | 73.66 | 6.28 | 0 | 474.86 |
| **Weekly number of monkeypox cases in Germany** | 8.71 | 17.17 | 0 | 71 |
| **Weekly number of monkeypox cases in UK** | 8.61 | 15.73 | 0 | 78.71 |
| **Weekly rate of monkeypox cases per 1,000,000 people in Canada** | 0.09 | 0.0078 | 0 | 0.609 |
| **Weekly rate of monkeypox cases per 1,000,000 people in the USA** | 0.22 | 0.38 | 0 | 1.40 |
| **Weekly rate of monkeypox cases per 1,000,000 people in Germany** | 0.10 | 0.21 | 0 | 0.85 |
| **Weekly rate of monkeypox cases per 1,000,000 in UK** | 0.13 | 0.23 | 0 | 1.17 |

The data for this study covered from 2022 to July 2023. The variables used for data analysis are shown in Table 1, along with their characteristics, such as mean, median, range, minimum and maximum values (Sergev et al., 2022). From May 2022 to July 2023, Canada has seen an average of 3.63 new monkeypox cases weekly. The standard deviation for Canada is near the mean. In the USA since the start of the 2022 monkeypox outbreak, the average number of cases reported each week have been 73.66, with a lot of variability, as evidenced by the maximum of 474 cases reported during the week of August 18th, 2022, to August 23rd, 2022. The average number of monkeypox cases appearing weekly in the UK is 8.61, with a standard deviation of 15.73. Moreover, the maximum number of weekly cases reported in the UK during the study period was 78 on August 2nd, 2022. The weekly rate of monkeypox cases in Germany ranged from 0 per 1,000,000 people on May 20th, 2022, to a maximum of 0.85 per 1,000,000 people on July 21st, 2022.

**Graphical Univariate Analysis**

A group of graphs and diagrams

Description automatically generated

**Fig. 1. Graphical Univariate Analysis of weekly cases for Canada**

A group of graphs showing different types of cases

Description automatically generated

**Fig. 2. Graphical Univariate Analysis of weekly cases for USA**

A group of graphs showing different types of cases

Description automatically generated

**Fig. 3. Graphical Univariate Analysis of weekly cases for the UK**

A group of graphs showing different cases

Description automatically generated with medium confidence

**Fig. 4. Graphical Univariate Analysis of weekly cases for Germany**

These graphical representations of the weekly monkeypox cases illustrate that each country has outliers in its data, as indicated by their boxplots. Further, Canada, USA, the United Kingdom, and Germany have heavy right-skewed distributions. We will model the distribution with linear regression and Poisson distribution and compare the results.

**Results and Discussion**

**Simple Linear Regression**

Using the FORECAST.LINEAR method in Excel weekly cumulative monkeypox cases for Canada, USA, the UK, and Germany were forecasted for eight weeks following 17/07/2023. The estimates are shown below.

**Fig. 5. Prediction of weekly cumulative monkeypox cases for Canada**

**Fig. 6. Prediction of weekly cumulative monkeypox cases for USA**



**Fig. 7. Prediction of weekly cumulative monkeypox cases for UK**

**Fig. 8. Prediction of weekly cumulative monkeypox cases for Germany**

Figure 5 shows the cumulative cases in Canada over the next two months. The trend of monkeypox cases in Canada is steadily decreasing. By the end of the forecasting period on September 17, 2023, cumulative monkeypox cases in Canada will drop to 1,613. According to the linear forecasting method, Canada’s monkeypox outbreak peaked on July 18, 2023, and approximately 1,782 people were infected. The big jump between the second and third weeks of July 2023 may be attributed to the skewedness of the underlying distribution, which is why it did not provide us with a good forecast. Moreover, Excel’s linear forecast gives a better curve fit that looks like a logistic function, so it is not a linear regression, as a linear regression would have given us a straight line. Linear forecasting does not work hence Poisson regression is more appropriate for making predictions since the outcome variable is represented by count data.

Figure 6 shows the cumulative cases in USA over the next two months. The trend of monkeypox cases in the USA is steadily decreasing. By the end of the forecasting period on September 17, 2023, cumulative monkeypox cases in the UK will drop to 36,318. According to the linear regression method, the USA’s monkeypox outbreak will peak on August 4, 2023, and approximately 38,625 people will be infected. The big jump between the second and third weeks of July 2023 may be attributed to the skewedness of the underlying distribution, which is why it did not provide us with a realistic estimation. Moreover, Excel’s linear forecast gives a better curve fit that looks like a logistic function, so it is not a linear regression, as a linear regression would have given us a straight line. Linear forecasting does not work hence Poisson regression is more appropriate for making predictions.

Figure 7 shows the cumulative cases in UK over the next two months. The trend of monkeypox cases in the UK is steadily decreasing. By the end of the forecasting period on September 17, 2023, cumulative monkeypox cases in the UK will drop to 4,224. According to the linear forecasting method, the UK’s monkeypox outbreak peaked on July 18, 2023, and approximately 4,627 people will be infected. The big jump between the second and third weeks of July 2023 may be explained by the skewedness of the underlying distribution, which is why it did not provide us with a good forecast. Moreover, Excel’s linear forecast gives a better curve fit that looks like a logistic function, so it is not a linear regression, as a linear regression would have given us a straight line. Because the outcome variable is represented by count data, Poisson regression is a better method of making predictions.

Figure 8 shows the cumulative cases in Germany over the next two months. The trend of monkeypox cases in Germany is steadily decreasing. By the end of the forecasting period on September 17, 2023, cumulative monkeypox cases in Germany will drop to 3,957. According to the linear forecasting method, Germany’s monkeypox outbreak peaked on July 18, 2023, and approximately 4,476 people were infected. The big jump between the second and third weeks of July 2023 may be related to the skewed distribution of the underlying data, which is why it was not very useful for forecasting. Moreover, Excel’s linear forecast gives a better curve fit that looks like a logistic function, so it is not a linear regression, as a linear regression would have given us a straight line. A Poisson regression is more appropriate for making predictions since the outcome variable is represented by counts.

**Poisson Time Series Regression**

I developed a Poisson time series regression (ISEE Global Education Channel, 2018) using weekly new cases smoothed variable for Canada, the USA, the UK and Germany over the study period. The estimates are shown below.

**A graph of a graph showing the number of cases

Description automatically generated**

**Fig. 9. Weekly confirmed monkeypox cases for Canada**

Monkeypox cases in Canada peaked from June 2022 to August 2022, then declined until July 2023. The number of monkeypox cases in Canada is steadily decreasing. Canada’s daily monkeypox cases are close to 0 from January 2023 to July 11th, 2023 (Edouard Mathieu *et al.*, 2022), and it can be concluded that the 2022 outbreak is coming to an end in Canada until there is a new outbreak, re-emergence of monkeypox.

Call:

glm(formula = a ~ bs(x, knots = 8) + as.factor(b), family = quasipoisson("log"),

data = data)

Coefficients: (1 not defined because of singularities)

Estimate Std. Error t value Pr(>|t|)

(Intercept) 0.041363 0.813517 0.051 0.9595

bs(x, knots = 8)1 1.891005 0.853893 2.215 0.0273 \*

bs(x, knots = 8)2 6.597014 0.952377 6.927 1.72e-11 \*\*\*

bs(x, knots = 8)3 -11.687429 2.132600 -5.480 7.51e-08 \*\*\*

bs(x, knots = 8)4 NA NA NA NA

as.factor(b)Monday 0.011458 0.258610 0.044 0.9647

as.factor(b)Saturday 0.003716 0.258586 0.014 0.9885

as.factor(b)Sunday 0.007536 0.258594 0.029 0.9768

as.factor(b)Thursday -0.003607 0.258585 -0.014 0.9889

as.factor(b)Tuesday 0.020886 0.258610 0.081 0.9357

as.factor(b)Wednesday -0.007103 0.258593 -0.027 0.9781

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for quasipoisson family taken to be 7.144539)

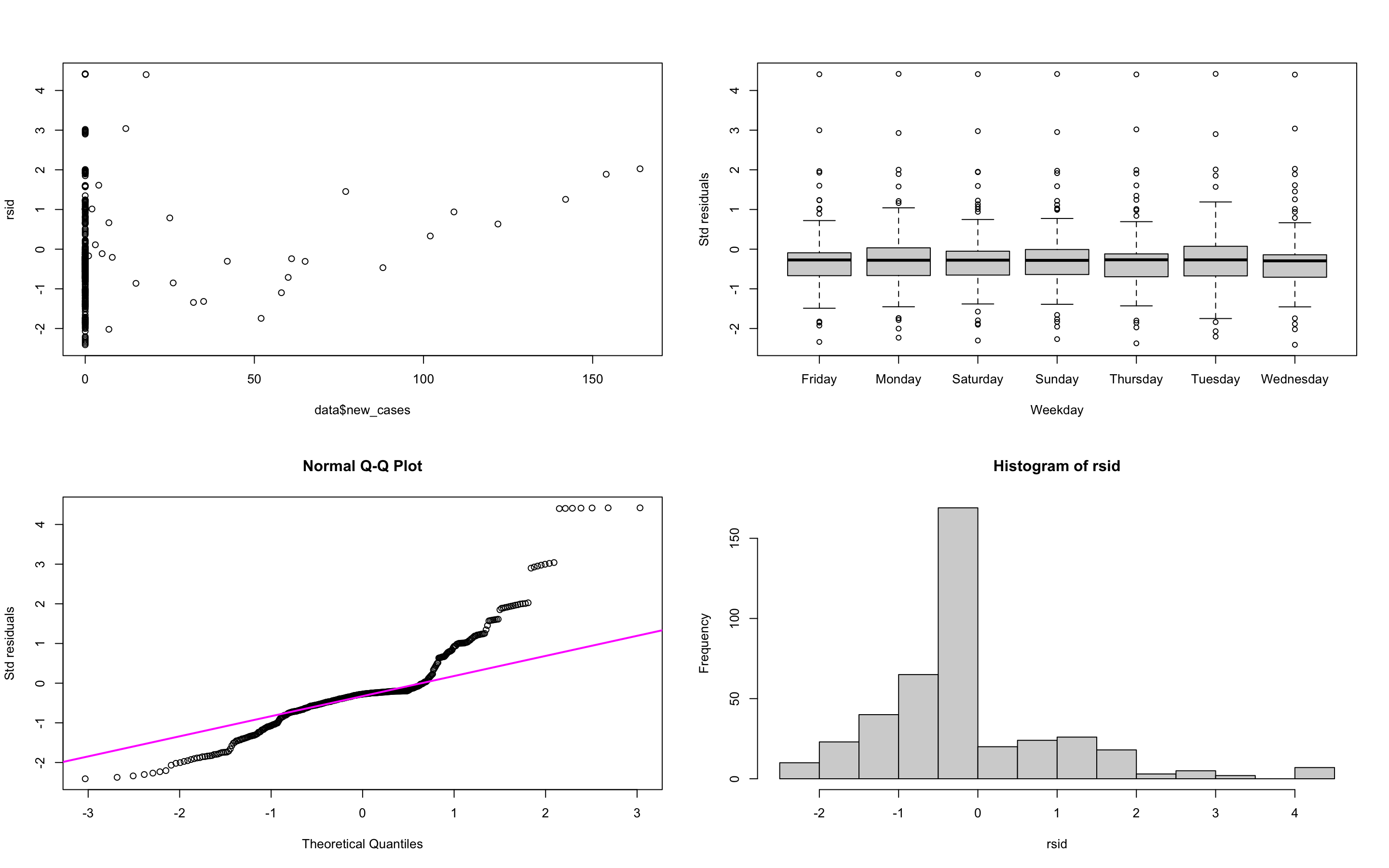
Null deviance: 3448.54 on 411 degrees of freedom

Residual deviance: 548.35 on 402 degrees of freedom

AIC: NA

Number of Fisher Scoring iterations: 7

**Output of fitted time series regression model of weekly monkeypox cases for Canada**

**Fig. 10. Canada’s modelling assumptions**

By plotting the residuals based on the deviance residuals, we can see that Canada’s data does not appear to be normal, and the residuals throughout the week contain many outliers, suggesting that the data is not normal. Canada’s residual histogram shows a single mode and an unsymmetrical pattern. It’s probability plot has a line that is not normal, illustrating that the data may be skewed. Thus, the residuals are not distributed normally. In this model, the dispersion parameter is 7.14. Using the quasipoisson family to model the time series regression is justified due to the overdispersion.

**A graph showing a number of cases

Description automatically generated**

**Fig. 11. Weekly confirmed monkeypox cases for USA**

Monkeypox cases in the USA peaked from June 2022 to August 2022, then declined until July 2023. The number of monkeypox cases in the USA is steadily decreasing. The United States’ daily monkeypox cases are close to 0 from December 2022 remaining relatively unchanged until July 11th, 2023 (Edouard Mathieu *et al.*, 2022), and it can be concluded that the 2022 outbreak is coming to an end in the USA unless there is a new outbreak, re-emergence of monkeypox.

Call:

glm(formula = a ~ bs(x, knots = 8) + as.factor(b), family = quasipoisson("log"),

data = data)

Coefficients: (1 not defined because of singularities)

Estimate Std. Error t value Pr(>|t|)

(Intercept) 3.151e+00 3.676e-01 8.571 2.24e-16 \*\*\*

bs(x, knots = 8)1 -1.541e+00 4.350e-01 -3.543 0.000442 \*\*\*

bs(x, knots = 8)2 1.312e+01 5.212e-01 25.182 < 2e-16 \*\*\*

bs(x, knots = 8)3 -1.619e+01 9.603e-01 -16.863 < 2e-16 \*\*\*

bs(x, knots = 8)4 NA NA NA NA

as.factor(b)Monday -2.367e-03 1.082e-01 -0.022 0.982560

as.factor(b)Saturday -6.946e-04 1.082e-01 -0.006 0.994880

as.factor(b)Sunday -1.479e-03 1.082e-01 -0.014 0.989100

as.factor(b)Thursday 6.165e-04 1.082e-01 0.006 0.995456

as.factor(b)Tuesday 1.736e-03 1.082e-01 0.016 0.987207

as.factor(b)Wednesday 1.165e-03 1.082e-01 0.011 0.991415

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for quasipoisson family taken to be 25.37738)

Null deviance: 67406.6 on 411 degrees of freedom

Residual deviance: 5985.7 on 402 degrees of freedom

AIC: NA

Number of Fisher Scoring iterations: 6

**Output of fitted time series regression model of weekly monkeypox cases for USA**

**A group of graphs and diagrams

Description automatically generated**

**Fig. 12. USA’s modelling assumptions**

By plotting the residuals based on the deviance residuals, we can see that the USA’s data appears to be normal, and the residuals throughout the week suggest that the data is normal. The USA’s residual histogram shows a single mode and a symmetrical pattern, and its probability plot has a straight line, illustrating that the data is normal. Thus, the residuals are distributed normally. In this model, the dispersion parameter is 25.38. Using the quasipoisson family to model the time series regression is justified due to the overdispersion.

**A graph showing the number of cases

Description automatically generated**

**Fig. 13. Weekly confirmed monkeypox cases for UK**

Monkeypox cases in the UK peaked from May 2022 to the end of July 2022, then declined until July 2023. The number of monkeypox cases in the UK is steadily decreasing. The UK’s daily monkeypox cases are close to 0 from November 2022 to July 11th, 2023 (Edouard Mathieu *et al.*, 2022), and it can be concluded that the 2022 outbreak is coming to an end in the UK unless there is a new outbreak, re-emergence of monkeypox.

Call:

glm(formula = a ~ bs(x, knots = 8) + as.factor(b), family = quasipoisson("log"),

data = data)

Coefficients: (1 not defined because of singularities)

Estimate Std. Error t value Pr(>|t|)

(Intercept) 9.177e-01 6.368e-01 1.441 0.150

bs(x, knots = 8)1 1.381e-02 6.870e-01 0.020 0.984

bs(x, knots = 8)2 1.259e+01 8.602e-01 14.631 <2e-16 \*\*\*

bs(x, knots = 8)3 -2.133e+01 1.792e+00 -11.899 <2e-16 \*\*\*

bs(x, knots = 8)4 NA NA NA NA

as.factor(b)Monday -5.327e-03 1.599e-01 -0.033 0.973

as.factor(b)Saturday -4.591e-03 1.599e-01 -0.029 0.977

as.factor(b)Sunday -4.952e-03 1.599e-01 -0.031 0.975

as.factor(b)Thursday -1.553e-04 1.599e-01 -0.001 0.999

as.factor(b)Tuesday -5.033e-04 1.599e-01 -0.003 0.997

as.factor(b)Wednesday -2.947e-04 1.599e-01 -0.002 0.999

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for quasipoisson family taken to be 6.868135)

Null deviance: 9435.71 on 436 degrees of freedom

Residual deviance: 824.55 on 427 degrees of freedom

AIC: NA

Number of Fisher Scoring iterations: 7

**Output of fitted time series regression model of weekly monkeypox cases for UK**

**A group of graphs and diagrams

Description automatically generatedFig. 14. UK’s modelling assumptions**

By plotting the residuals based on the deviance residuals, we can see that the UK’s data does not appear to be normal, and the residuals throughout the week contain many outliers, suggesting that the data is not normal. The UK’s residual histogram shows a single mode and an unsymmetrical pattern. It’s probability plot has a line that is not normal, illustrating that the data may be skewed. Thus, the residuals are not distributed normally. In this model, the dispersion parameter is 6.89. Using the quasipoisson family to model the time series regression is justified due to the overdispersion.

A graph showing the number of cases

Description automatically generated

**Fig. 15. Weekly confirmed monkeypox cases for Germany**

Monkeypox cases in Germany peaked from May 2022 to the first week of August 2022, then declined until July 2023. The number of monkeypox cases in Germany is steadily decreasing. Germany’s daily monkeypox cases are close to 0 from October 2022 to July 11th, 2023 (Edouard Mathieu *et al.*, 2022), and it can be concluded that the 2022 outbreak is coming to an end in Germany unless there is a new outbreak, re-emergence of monkeypox.

Call:

glm(formula = a ~ bs(x, knots = 8) + as.factor(b), family = quasipoisson("log"),

data = data)

Coefficients: (1 not defined because of singularities)

Estimate Std. Error t value Pr(>|t|)

(Intercept) -7.264e-01 5.202e+00 -0.140 0.88901

bs(x, knots = 8)1 1.907e+00 5.284e+00 0.361 0.71842

bs(x, knots = 8)2 1.590e+01 5.542e+00 2.869 0.00432 \*\*

bs(x, knots = 8)3 -2.863e+01 9.611e+00 -2.979 0.00306 \*\*

bs(x, knots = 8)4 NA NA NA NA

as.factor(b)Monday 1.580e-03 5.132e-01 0.003 0.99755

as.factor(b)Saturday 4.899e-04 5.132e-01 0.001 0.99924

as.factor(b)Sunday 1.017e-03 5.132e-01 0.002 0.99842

as.factor(b)Thursday 5.126e-03 5.132e-01 0.010 0.99204

as.factor(b)Tuesday 3.341e-03 5.132e-01 0.007 0.99481

as.factor(b)Wednesday 4.240e-03 5.132e-01 0.008 0.99341

---

Signif. codes: 0 ‘\*\*\*’ 0.001 ‘\*\*’ 0.01 ‘\*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for quasipoisson family taken to be 69.43403)

Null deviance: 10269.40 on 423 degrees of freedom

Residual deviance: 486.45 on 414 degrees of freedom

AIC: NA

Number of Fisher Scoring iterations: 8

**Output of fitted time series regression model of weekly monkeypox cases for Germany**

A group of graphs and diagrams

Description automatically generated

**Fig. 16. Germany’s modelling assumptions**

By plotting the residuals based on the deviance residuals, we can see that Germany’s data does not appear to be normal, and the residuals throughout the week contain many outliers, suggesting that the data is not normal. Germany’s residual histogram shows a single mode and an unsymmetrical pattern. It’s probability plot has a line that is not normal, illustrating that the data may be skewed. Thus, the residuals are not distributed normally. In this model, the dispersion parameter is 69.43. Using the quasipoisson family to model the time series regression is justified due to the overdispersion.

**Conclusion**

We used Poisson time series to model monkeypox cases over the study period obtained from Our World in Data website for Canada, the USA, the UK and Germany using the weekly new cases smoothed variable. As a result of evaluating model assumptions, the residuals for Canada, the USA and the UK are not normal and overdispersion is present in all models, indicating that the Poisson time series regression performs well. By comparing model performance of linear forecasting to Poisson time series, we found that linear regression is not representative of the data since the underlying distribution is skewed and the Poisson time series regression is more accurate.

**References**

Dou, Y. M., Yuan, H., & Tian, H. W. (2023). Monkeypox virus: past and present. In *World Journal of Pediatrics* (Vol. 19, Issue 3). https://doi.org/10.1007/s12519-022-00618-1

Edouard Mathieu, Fiona Spooner, Saloni Dattani, Hannah Ritchie, & Max Roser. (2022). Mpox (monkeypox). *Our World in Data*. https://ourworldindata.org/monkeypox

*Factsheet for health professionals on mpox (monkeypox)*. (n.d.). European Centre for Disease Prevention and Control.

Farrington, C. P., Andrews, N. J., Beale, A. D., & Catchpole, M. A. (1996). A Statistical Algorithm for the Early Detection of Outbreaks of Infectious Disease. *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, *159*(3). https://doi.org/10.2307/2983331

Goyal, L., Ajmera, K., Pandit, R., & Pandit, T. (2022). Prevention and Treatment of Monkeypox: A Step-by-Step Guide for Healthcare Professionals and General Population. *Cureus*. https://doi.org/10.7759/cureus.28230

ISEE Global Education Channel. (2018, March 14). *JOEL SCHWARTZ - Poisson time series*. Youtube. https://www.youtube.com/watch?v=6mIUmAUj0I0

Lulli, L. G., Baldassarre, A., Mucci, N., & Arcangeli, G. (2022). Prevention, Risk Exposure, and Knowledge of Monkeypox in Occupational Settings: A Scoping Review. In *Tropical Medicine and Infectious Disease* (Vol. 7, Issue 10). https://doi.org/10.3390/tropicalmed7100276

Reynolds, M. G., & Damon, I. K. (2012). Outbreaks of human monkeypox after cessation of smallpox vaccination. In *Trends in Microbiology* (Vol. 20, Issue 2). https://doi.org/10.1016/j.tim.2011.12.001

Sergev, A., Lalonde, C., & Pons, W. (2022). The role of climate change in the spread of vectors and vector-borne disease in Windsor-Essex County. *The Journal of the Canadian Institute of Public Health Inspectors*.

World Health Organization. (2022). *Mpox (monkeypox) outbreak 2022 - Global*. https://www.who.int/emergencies/situations/monkeypox-oubreak-2022

World Health Organization. (2023, April 18). *Mpox (Monkeypox)*. https://www.who.int/news-room/fact-sheets/detail/monkeypox