A comparison of multilevel ordinal regression models in the analysis of police force ratings

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SUMMARY

In the literature several methods have been developed to model ordinal data while considering their natural ordering. However, this study sought to compare two possible link functions for the multilevel ordinal regression using males' ratings of the police forces in Uganda as an outcome variable. Variables were obtained from the UNGBS database (Uganda National Governance Baseline Survey). The highest proportion of males rated the police as good (40.9%) followed by fair (24.96%), poor (19.1%), and lastly very good (15.1%). The multilevel ordered logistic regression model with both individual and contextual variables had the lowest AIC compared to other models, fitting the data best. All the likelihood ratio test results indicated that there was significant variation in males' ratings of the police forces across districts. Hence, males from the same district were significantly more similar compared to males from another districts. Researchers using data collected by applying multi–stage sampling or any form of nesting should consider multilevel or mixed–effects models.

KEYWORDS

logit, ordinal regression, police rating, probit, Uganda

1. Introduction

Many methods use outcome variable measured on the Likert–type scale. It is essentially an ordinal scale measure that provides a range of ranked responses to a given statement or question (Jamieson, 2004; Wu and Leung, 2017). Other scales for generating ordinal variables include fuzzy sets, semantic differential scales, feeling thermometers, and Stapel scales (Lalla, 2017). Ordinal data can be analyzed by dichotomizing it and using logistic regression, treating it like it's measured on an interval scale and using linear regression (Šarlija and Stanić, 2017), ignoring the natural ordering and using multinomial logistic regression or use methods tailored to specifically ordinal data. Although the response options for ordinal data have numerical labels, this doesn't mean that they have metric information and therefore should

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not be analyzed using metric methods. Several researchers have analyzed ordinal data using metric methods under the assumption that data is on an interval or ratio measurement scale and therefore its presumed intervals between response levels are equal which is incorrect resulting in wrong interpretations (Liddell and Kruschke, 2018).

A survey of articles in three psychology journals that used the Likert scale found that all articles analyzed ordinal data using a metric model (Liddell and Kruschke, 2018). Other demerits of analyzing ordinal outcomes using metric methods such as ordinary linear regression include results being sensitive to the assigned scores or ratings, not making provision for measuring the error associated with replacing the ordinal responses with continuous ones, predicting values beyond the range of possible ordinal outcomes (Fernandez et al., 2019), detecting effects when they don't exist, not detecting effects when they exist (Liddell and Kruschke, 2018). Also, dichotomizing ordinal outcomes and analyzing them using the logistic regression model has been found to reduce both the precision and power considerably (Sankey and Weissfeld, 1998; Fernandez et al., 2019). Several methods have been developed to model ordinal data while taking into consideration their natural ordering, e.g. Sabek (2023). These have other merits such as having fewer assumptions, more power for identifying important trends, and the use of methods analogous to methods in ordinary regression involving numeric variables (Fernandez et al., 2019). According to previous studies of Abreu et al. (2008); Fullerton and Xu (2012); Liu and Koirala (2013); Lelisho et al. (2022), ordinal regression models include the proportional odds model (POM), unrestricted prtial proportional odds model (UPPOM), restricted partial, proportional odds model (RPPOM), continuous ratio model (CRM), adjacent category model (ACM) and stereotype model (SM). The POM is the most popular across different statistical software such as Stata, R, SAS, SPSS, etc. for analyzing ordinal outcomes (Liu and Koirala, 2013).

The most common link function for fitting ordinal regression models is the logit link (Smith et al., 2020). Alternative link functions include the complementary log–log (cloglog), negative log–log (nloglog), Cauchit, and probit link functions (Yay and Akinci, 2009; Smith et al., 2020). The logit link function is recommended when categories or ordinal outcomes are evenly or uniformly distributed. The clogog is preferable when higher categories are more likely or when outcomes are negatively skewed. The nloglog is ideal when lower categories are more likely or when outcomes are positively skewed. The Cauchit is suitable for ordinal outcomes with several extreme values and the probit for analyses involving explicitly normally distributed latent variables or outcomes with latent, underlying normal distribution (Smith et al., 2020).

Studies which employ the ordered logistic regression often deal with cross–sectional data (Das and Rahman, 2011; Singh et al., 2020; Mathew et al., 2021; Lelisho et al., 2022). However, cross–sectional data are usually collected using complex survey methods and have some hierarchical structure with the ultimate sampling units being nested within primary or secondary sampling units. Neglecting the hierarchies or clusters can result in the overestimation of standard errors for regression coefficients resulting in lower power for tests of predictor variable effects, type one errors, etc. (Moerbeek, 2004; Van den Noortgate, et al., 2005). Therefore this study will use cross–sectional data collected by multistage sampling to compare the ordinary regression models for ordinal outcomes with probit and logit links to the multilevel regression models for ordinal outcomes, considering police forces rating. Given that institutions which provide formal support services to victims, e.g. the police, courts of law, play a vital role in curbing IPV (intimate partner violence) as well as promoting help–seeking by victims.

This research will therefore ascertain the factors that influence males' ratings of these institutions, specifically the police in the delivery of justice. This is important because regardless of the existence of these institutions, if victims don't hold them in high regard concerning the provision of justice when harmed or the provision of protection from harm, they won't seek their services and this will frustrate all efforts by the government and other key stakeholders to reduce the high rates of IPV and low help–seeking in Uganda.

2. Materials and methods

The data was retrieved from the Uganda National Governance Baseline Survey 2013. The study adopted a three–stage cluster sampling design. Firstly, using probability proportional to size (PPS), a selection of 75 enumeration areas (EAs) was done from all strata. Secondly, systematic sampling was used to choose 10 households from the selected EAs. Altogether, 750 households were chosen per strata. In the final stage, a male and a female adult were chosen from each household for interview (UBOS, 2014).

The outcome variable for this study was the male rating of the Uganda Police Force (UPF) in the delivery of justice in their communities. Explanatory variables for this study were age, region, residence, district, marital status, education level, aware of right to seek justice, respect for human rights, coerced by police against seeking justice, police involvement in corruption, and courts involvement in corruption.

Software STATA 15.0 was used to perform analysis in all three stages. Firstly, frequencies and percentages were used to conduct a descriptive summary of all the variables in the study. Secondly, Pearson's chi–square test was used to test the association between the dependent variables and the plausible independent variables. Independent variables with a significant association (p–value < 0.05) were considered for further analysis.

Since the outcome variable was ordered, regression models for ordinal outcomes were used to identify the factors associated with a male's ratings of the UPF. STATA provides regression models for ordinal outcomes with probit and logit link functions. Multilevel or mixed–effects models were utilized since the collected data had clustering with individuals nested in districts. The mixed–effects ordered logistic regression and mixed–effects ordered probit regression models are presented in Equation 1 and Equation 2.

$$y_{ij}^{*} = \sum x_{ij}\beta_j + \mu_j + \varepsilon_{ij} \tag{1}$$

$$y_{ij} = \begin{cases} 1 & \text{if } y_{ij}^{*} \leq c_1 \\ 2 & \text{if } c_1 < y_{ij}^{*} \leq c_2 \\ & \vdots \\ C & \text{if } c_{c-1} < y_{ij}^{*} \end{cases} \tag{2}$$

were y_{ij}^{*} is a latent linear response for observed ordinal responses y_{ij}, β_j are fixed effects, μ_j are random effects, ε_{ij} are errors distributed as logistic with a zero mean and $\pi^2/3$ variance for a logit link and distributed as standard normal with 0 mean and 1 variance for a probit link, while C is the number of potential outcomes and c are the cut–points.

To test whether taking into consideration the hierarchical nature of the data improves the model fit, the ordinary ordered logistic regression model and ordered probit regression

model were estimated. Overall, for multivariate analysis, five models were fitted concerning the possible link functions. The null model with no independent variables, the model inclusive of contextual level independent variables only, the model inclusive of individual level variables only, the model inclusive of individual and contextual level independent variables concurrently, and finally the single–level (ordinary ordered logistic or ordered probit regression disregarding the nesting in the data). To identify which model fits the data best, the Akaike Information Criteria (AIC) was used. The model with the lowest AIC value (Equation 3) was regarded as the best and reported.

$$AIC = -2lnL + 2k \tag{3}$$

Maximized log–likelihood is denote as lnL, and k is the number of estimated parameters.

3. Results and discussion

A summary of the survey respondents characteristics is provided in Table 1. The highest proportion of males rated the police as good (40.9%) followed by fair (24.96%), poor (19.1%), and lastly very good (15.1%). The highest proportion of males was aged 50 and above (20.3%), from eastern Uganda (22.6%), rural residents (72.5%), in monogamous marriages (60.7%), and with primary education level (52.6%). The majority of the males were aware of their right to seek justice (89.7%), thought human rights are respected in Uganda (72.7%), had never been coerced against seeking justice by the police (96.9%), and thought the police is very much involved in corruption (69.2%). A high proportion of males knew how to lodge a complaint with the police (73.4%), had moderate trust in the police (38.6%) and resided less than 3 kilometers from the nearest police station (44.8%).

Table 1. *Characteristics of the survey respondents*

Variables		Frequency	Percent
Rating of police force	Poor	402	19.1
	Fair	524	24.9
	Good	860	40.9
	Very good	318	15.1
Age	18 to 24	341	16.2
	25 to 29	338	16.1
	30 to 34	323	15.4
	35 to 39	278	13.2
	40 to 49	398	18.9
	50+	426	20.3
Region	Kampala	369	17.5
	Central	416	19.8
	Eastern	475	22.6
	Northern	423	20.1
	Western	421	20.0
Residence	Rural	1524	72.5
	Urban	579	27.4

Marital status	Never married	343	16.3
	Married monogamy	1276	60.7
	Married polygamy	262	12.5
	Cohabiting	76	3.6
	Divorced/separated	102	4.9
	Widowed	45	2.1
Education level	None	260	12.4
	Primary	1106	52.6
	Secondary	489	23.2
	Diploma/certificate	142	6.8
	Degree and above	107	5.1
Aware of right to seek justice	No	216	10.3
	Yes	1888	89.7
Respect for human rights	No	575	27.3
	Yes	1529	72.7
Coerced by police	No	2039	96.9
	Yes	65	3.1
Police involvement in corruption	Not at all	111	5.3
	Slightly	222	10.6
	Somewhat	315	15.0
	Very much	1456	69.2
Lodge complaint with police	No	516	24.5
	Yes	1544	73.4
	Don't know	44	2.1
Level of trust in police	Low	652	31.0
	Moderate	811	38.6
	High	610	29.0
	Not applicable	31	1.5
Distance to nearest police station	< 3 km	939	44.8
	$3 - 5$ km	540	25.8
	> 5 km	617	29.4

Table 2 presents a summary of results for the association between a male's ratings of the police and the plausible independent variables. The significant independent variables include age, region, residence, education level, awareness of one's right to seek justice, thoughts on respect of human rights, whether one had ever been coerced against seeking justice by police, whether one thought the police was involved in corruption, and one's level of trust in the police. Males aged 50 years and above (21.4%) had the highest proportion rating the police as very good whereas those aged 30 to 34 years had the highest rating the police as poor (23.2%). Males from the western region (22.6%) had the highest proportion rating the police as very good whereas Kampala (24.1%) had the highest proportion rating the police as poor. The highest proportion of males residing in rural areas (42.4%) and urban areas (36.8%) rated the police as good. Approximately half of males with a education degree and above (50.5%) rated the police as fair whereas those with no formal education (49.2%) had the highest proportion rating the police as good.

Table 2. *Relationship between male's ratings of the police and independent variables*

Variable		Rating of police force				n	p–value
		Poor	Fair	Good	Very good		
Age	18 to 24	16.7	26.4	42.8	14.1	341	0.006
	25 to 29	19.2	26.3	43.2	11.2	338	
	30 to 34	23.2	27.2	37.2	12.4	323	
	35 to 39	21.2	22.3	44.2	12.2	278	
	40 to 49	18.3	26.4	38.4	16.8	398	
	50+	17.1	21.1	40.4	21.4	426	
Region	Kampala	24.1	31.2	35.8	8.9	369	0.000
	Central	21.6	25.0	38.9	14.4	416	
	Eastern	13.5	22.1	42.5	21.9	475	
	Northern	18.0	26.7	49.2	6.2	423	
	Western	19.7	20.7	37.1	22.6	421	
Residence	Rural	17.8	23.1	42.4	16.7	1525	0.000
	Urban	22.5	29.7	36.8	11.1	579	
Marital status	Never married	19.5	28.3	40.5	11.7	343	0.294
	Married monogamy	19.2	24.5	40.6	15.8	1,276	
	Married polygamy	18.7	23.3	39.3	18.7	262	
	Cohabiting	15.8	26.3	52.6	5.3	76	
	Divorced/separated	21.6	24.5	39.2	14.7	102	
	Widowed	15.6	20.0	44.4	20.0	45	
Education level	None	16.2	16.2	49.2	18.5	260	0.000
	Primary	18.6	20.4	44.0	16.9	1,106	
	Secondary	19.0	30.7	36.0	14.3	489	
	Diploma/certificate	24.7	36.6	33.1	5.6	142	
	Degree & above	24.3	50.5	20.6	4.7	107	
Aware of right to seek justice	No	20.4	22.2	44.0	13.4	216	0.589
	Yes	19.0	25.2	40.5	15.3	1888	
Respect for human rights	No	34.6	31.7	25.9	7.8	575	0.000
	Yes	13.3	22.4	46.5	17.9	1529	
Coerced by police	No	17.9	24.8	41.9	15.4	2039	0.000
	Yes	58.5	27.7	7.7	6.2	65	
Police involvement in corruption	Not at all	4.5	9.0	51.4	35.1	111	0.000
	Slightly	8.6	15.8	53.2	22.5	222	
	Somewhat	9.5	29.5	43.8	17.1	315	
	Very much	23.9	26.5	37.6	12.0	1,456	
Lodge complaint with police	No	19.0	21.7	42.1	17.3	516	0.190
	Yes	18.9	26.0	40.6	14.6	1544	
	Don't know	29.6	25.0	36.4	9.1	44	
Level of trust in police	Low	48.6	32.8	16.1	2.5	652	0.000
	Moderate	7.3	31.7	54.4	6.7	811	
	High	3.4	7.4	48.9	40.3	610	
	Not applicable	16.1	25.8	51.6	6.5	31	
Distance to nearest police station	< 3 km	19.3	27.1	37.8	15.9	939	0.183
	$3 - 5$ km	18.9	24.6	42.0	14.4	540	
	> 5 km	19.0	21.9	44.4	14.8	617	

The highest proportion of males who thought there was respect for human rights in Uganda rated the police as good (46.5%) whereas for males who thought otherwise the highest proportion rated the police as poor (34.6%). The majority of males who had ever been coerced against seeking justice from the police rated the police as poor (58.5%) while the highest proportion of males who had never been coerced against seeking justice rated the police as good (41.9%). Males who thought the police were very much involved in corruption had the highest proportion rating the police as poor (23.9%) while those who thought the police were not at all involved in corruption (35.1%) had the highest proportion rating the police as very good. Males who had a high level of trust in the police had the highest proportion rating the police as very good (40.3%) while those who had low trust in the police had the highest proportion rating the police as poor (48.6%).

The results for some tests considered relevant to this study are summarized in Table 3. The likelihood ratio (LR) tested whether district–level variance was significant enough to support the usage of multilevel models instead of ordinary regression models. The variance partition (VP) coefficient was computed to provide an estimate of the level of clustering in the dataset. The multilevel ordered logistic regression model inclusive of individual and contextual level independent variables concurrently had the lowest AIC (4414.2) and fit the data best compared to other models. For this model, the VP coefficient was 0.04 which meant that 4 percent of the variation in males' ratings of the police was between districts. All likelihood ratio tests for the null hypotheses $H_0 : \sigma_u^2 = 0$ had p–values less than 0.05. Therefore, the variance between districts was significantly not equal to zero. Thus, males who had a district in common were significantly more similar compared to those from other districts. Therefore, multilevel models for analyzing ordinal outcomes were more suitable than single-level models based on the likelihood ratio test.

Table 3. *A comparison of plausible mixed–effects models*

Model	Type	Variance	Variance partition	Akaike info criterion	Likelihood ratio test
Oredered logit	Single–level	–	–	4426.5	–
	Null model	0.26	0.07	5469.1	67.1***
	Contextual only	0.20	0.06	5458.4	32.8***
	Individual only	0.17	0.05	4416.9	18.6***
	Individual and contextual	0.14	0.04	4414.2	14.3***
Ordered probit	Single–level	–	–	4449.8	–
	Null model	0.09	0.08	5469.6	66.5***
	Contextual only	0.07	0.06	5457.3	31.9***
	Individual only	0.06	0.06	4437.5	20.8***
	Individual and contextual	0.05	0.05	4435.6	16.2***

Note: significance levels are denoted as follows: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4 presents a summary of the results for the mixed–effects ordered logistic regression for the rating of the police by males in Uganda. Regarding education level, for males with degrees and above, the odds of rating the police as very good versus good, fair, or poor were 0.63 times lower than for males with no formal education. For males who thought there was respect for human rights in Uganda, the odds of rating the police as very good versus good, fair, or poor were 2 times higher than for males who thought there was no respect

for human rights in Uganda. For males who thought the police were very much involved in corruption, the odds of rating the police as very good versus good, fair, or poor were 0.47 times lower than for males who thought the police were not at all involved in corruption. For males who had ever been coerced against seeking justice by the police, the odds of rating the police as very good versus good, fair, or poor were 0.29 times lower than for males who had never been coerced against seeking justice by the police. For males who had a moderate level of trust in the police, the odds of rating the police as very good versus good, fair, or poor were 6.84 times higher than for males who had a low level of trust in the police. Still, for males who had a high level of trust in the police, the odds of rating the police as very good versus good, fair or poor are 40.13 times higher than for males who had a low level of trust in the police.

Table 4. *Mixed–effects ordered logistic regression of male's ratings of the police*

Variables		AOR	*p*–value	95% confidence limits	
Age	18 to 24 (ref.)	1.00			
	25 to 29	1.09	0.57	0.81	1.46
	30 to 34	0.95	0.73	0.70	1.28
	35 to 39	1.16	0.36	0.85	1.59
	40 to 49	1.25	0.13	0.93	1.66
	50+	1.14	0.38	0.85	1.52
Region	Kampala (ref.)	1.00			
	Central	1.44	0.37	0.65	3.21
	Eastern	1.58	0.26	0.71	3.50
	Northern	0.93	0.87	0.42	2.08
	Western	1.20	0.66	0.54	2.69
Residence	Rural (ref.)	1.00			
	Urban	1.20	0.25	0.88	1.65
Education level	None (ref.)	1.00			
	Primary	1.10	0.51	0.83	1.46
	Secondary	1.11	0.54	0.80	1.52
	Diploma/certificate	0.86	0.47	0.56	1.30
	Degree & above	0.63	0.05	0.39	1.00
Respect for human rights	No (ref.)	1.00			
	Yes	2.00	0.00	1.63	2.44
Police involvement in corruption	Not at all (ref.)	1.00			
	Slightly	0.71	0.14	0.45	1.12
	Somewhat	0.70	0.11	0.45	1.09
	Very much	0.47	0.00	0.32	0.70
Coerced by police	No (ref.)	1.00			
	Yes	0.29	0.00	0.17	0.51
Level of trust in police	Low (ref.)	1.00			
	Moderate	6.84	0.00	5.46	8.56
	High	40.13	0.00	30.08	53.53
	Not applicable	5.49	0.00	2.67	11.27

Note: AOR is adjusted odds ratio and (ref.) is the reference category

In this study, having a degree and above had a significant effect on one's rating of the police. This could be attributed to the connection between education level and trust in the police (Macdonald and Stokes, 2006; Clark et al., 2020) where persons with a lower education level will be likely to to trust the police more compared to persons with higher levels of education (Olutola and Bello, 2016). A study by Macdonald and Stokes (2006) reported that respondents with higher education reported that their local police were trustworthy. The low likelihood of rating the police as very good by those with degrees and above could also be attributed to them being more likely to notice police bias or other negative actions of the police (Wu, 2014; Clark et al., 2020). The increased likelihood of rating the police very good by males who thought the police respect human rights and those who trust in the police could be attributed to the public confidence that is built up through consistent professional and legal conduct by the police as opposed to reliance on using fear and physical force in fulfilling its mandate.

4. Conclusion

The study sought to compare two possible link functions for the ordinal regression model using data on males' ratings of the police in Uganda. Males who had a degree and above thought the police were very much involved in corruption, and had ever been coerced against seeking justice by the police were less likely to rate the police as very good. Still, males who thought there was respect for human rights in Uganda and had either moderate or high trust of trust in the police were more likely to rate the police as very good. Therefore, the police must endeavour to improve its reputation and build trust through initiatives aimed at ensuring human rights are observed and protected while fulfilling its mandate. This in turn will result in improved cooperation with citizens in ensuring law and order plus positive reviews or ratings of the police on the different indicators of police performance.

Based on the study findings, the use of multilevel models was preferable against ordinary regression models or single–level regression models since there were significant variations in the rating of the police by males across the districts of Uganda. Both the AIC and LR tests were in favour of the multilevel models over the single–level regression models for ordinal outcomes. Researchers using data collected by multi–stage sampling or with any form of nesting should consider using multilevel or mixed–effects models. Also, researchers should consider exploring link functions other than the logit when studying ordinal outcomes given that they could fit the data better and hence improve the quality of their results. Still, there is a need for more quantitative research concerning the performance of security institutions which can be enriched by qualitative research, especially in Sub–Saharan Africa where limited research has been done and yet numerous concerns have been raised about human rights abuse by the institutions charged with ensuring law and order.

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Usporedba višerazinskih modela ordinalne regresije u analizi rangiranja policijskih snaga

SAŽETAK

U literaturi je razvijeno nekoliko metoda za modeliranje ordinalnih podataka uzimajući u obzir njihov prirodni redoslijed. Međutim, ovo je istraživanje nastojalo usporediti dvije moguće vezne funkcije višerazinske ordinalne regresije koristeći rangove muškaraca o policijskim snagama u Ugandi kao varijablu ishoda. Varijable su prikupljene iz UNGBS baze podataka (engl. *Uganda National Governance Baseline Survey*). Najveći udio muškaraca policiju je ocijenio dobrom (40,9%), zatim osrednjom (24,96%), lošom (19,1%) i na kraju vrlo dobrom (15,1%). Višerazinski uređeni logistički regresijski model s pojedinačnim i kontekstualnim varijablama imao je najniži AIC u usporedbi s drugim modelima, najbolje se prilagođavajući podacima. Svi rezultati testa omjera vjerodostojnosti pokazali su postojanje značajne varijacije u rangiranju policijskih snaga od strane muškaraca u različitim okruzima. Dakle, muškarci iz istog okruga bili su znatno sličniji u odnosu na muškarce iz drugih okruga. Istraživači koji koriste podatke prikupljene primjenom višestupanjskog uzorkovanja ili bilo kojeg oblika ugniježđivanja trebali bi razmotriti modele s više razina ili modele s mješovitim učincima.

KLJUČNE RIJEČI

logit, ordinalna regresija, rangiranje policije, probit, Uganda

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