Thesis

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## Multinomial Logistic Regression

# @ Before covid

## Model with Non motorized transport as reference

weights: 96 (69 variable)  
initial value 555.904039   
iter 10 value 339.028466  
iter 20 value 303.333753  
iter 30 value 300.964946  
iter 40 value 300.613375  
iter 50 value 300.466458  
iter 60 value 300.445219  
iter 70 value 300.444679  
final value 300.444653   
converged

Call:  
multinom(formula = mode\_transport ~ primary\_trips + gender +   
 age + edu\_level + marital\_status + employ\_status, data = before)  
  
Coefficients:  
 (Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 4.810315 15.14049 -0.03918391  
Private\_transport 2.786763 14.77190 0.26902053  
Ride\_hailing 1.145325 15.78062 -0.21602452  
 primary\_tripswork genderMale age25 - 30 years  
Paratransit 0.5577615 -0.35595182 -0.21004105  
Private\_transport 0.4299208 -0.08204138 -0.50045099  
Ride\_hailing -0.3956315 -0.79496093 0.06630833  
 age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit 1.413133 -0.3147210 -3.328237470  
Private\_transport 1.200526 0.4629903 -0.477446024  
Ride\_hailing 1.127770 -0.6688093 -0.001580779  
 age61 and above ageunder 18 edu\_levelhigh school certififcate  
Paratransit 9.419343 0.7089661 -1.2725352  
Private\_transport 10.992166 -14.8401156 -1.9328261  
Ride\_hailing -6.690420 -15.2518581 -0.5791623  
 edu\_levelHND/diploma edu\_leveljunior high certificate  
Paratransit -0.01803108 -2.609267  
Private\_transport -0.45781289 -3.815663  
Ride\_hailing 0.70148175 -1.339544  
 edu\_levelno certificate and can not read  
Paratransit -3.446534  
Private\_transport -3.580986  
Ride\_hailing -22.117593  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit -1.1383307 10.331898  
Private\_transport -0.6677768 -3.453574  
Ride\_hailing -0.4573264 -3.053701  
 marital\_statusMarried marital\_statusseparated  
Paratransit 0.3608509 14.4804873  
Private\_transport 1.8285478 -0.7042954  
Ride\_hailing 0.9233415 -1.4642131  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit -0.2773978 -0.8263034  
Private\_transport 0.4923332 -0.3931386  
Ride\_hailing 0.1911608 -0.1200489  
 employ\_statusStudent employ\_statusUnemployed  
Paratransit -1.510954889 -1.442797  
Private\_transport -3.017149623 -1.989346  
Ride\_hailing -0.009251051 -1.141019  
  
Std. Errors:  
 (Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 1.676167 0.4063575 0.8357625  
Private\_transport 2.024319 0.5643798 0.9895940  
Ride\_hailing 2.120136 0.6058053 1.0782569  
 primary\_tripswork genderMale age25 - 30 years  
Paratransit 0.8056650 0.4981669 0.6332887  
Private\_transport 0.9426985 0.5665055 0.7542231  
Ride\_hailing 1.0761996 0.6456598 0.8499843  
 age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit 1.175863 1.394224 1.755070  
Private\_transport 1.271916 1.473979 1.546440  
Ride\_hailing 1.538584 1.892825 1.856444  
 age61 and above ageunder 18  
Paratransit 7.319573e-01 1.188504e+00  
Private\_transport 7.319546e-01 3.476493e-07  
Ride\_hailing 1.933734e-08 5.312778e-07  
 edu\_levelhigh school certififcate edu\_levelHND/diploma  
Paratransit 0.7650865 1.193914  
Private\_transport 0.8481416 1.256143  
Ride\_hailing 0.9228813 1.347457  
 edu\_leveljunior high certificate  
Paratransit 0.8467642  
Private\_transport 1.0784062  
Ride\_hailing 1.1180140  
 edu\_levelno certificate and can not read  
Paratransit 9.698866e-01  
Private\_transport 1.098140e+00  
Ride\_hailing 2.418753e-08  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit 1.274880 2.091435e-06  
Private\_transport 1.325564 1.250472e-06  
Ride\_hailing 1.539006 1.189923e-06

marital\_statusMarried marital\_statusseparated  
Paratransit 1.464947 2.078943e-06  
Private\_transport 1.787366 2.539181e-08  
Ride\_hailing 1.879942 3.016571e-08  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit 1.222788 0.9193655  
Private\_transport 1.590147 0.9531525  
Ride\_hailing 1.621697 1.1456086  
 employ\_statusStudent employ\_statusUnemployed  
Paratransit 0.948008 0.9954285  
Private\_transport 1.069716 1.1149037  
Ride\_hailing 1.155599 1.3369930  
  
Residual Deviance: 600.8893   
AIC: 738.8893

# Odds Ratios

(Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 122.770314 3762108 0.9615738  
Private\_transport 16.228396 2602272 1.3086820  
Ride\_hailing 3.143463 7135670 0.8057155  
 primary\_tripswork genderMale age25 - 30 years  
Paratransit 1.7467580 0.7005064 0.8105510  
Private\_transport 1.5371357 0.9212338 0.6062572  
Ride\_hailing 0.6732548 0.4515989 1.0685561  
 age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit 4.108809 0.7299925 0.03585625  
Private\_transport 3.321865 1.5888179 0.62036577  
Ride\_hailing 3.088760 0.5123183 0.99842047  
 age61 and above ageunder 18  
Paratransit 1.232448e+04 2.031889e+00  
Private\_transport 5.940692e+04 3.589382e-07  
Ride\_hailing 1.242761e-03 2.377947e-07  
 edu\_levelhigh school certififcate edu\_levelHND/diploma  
Paratransit 0.2801206 0.9821305  
Private\_transport 0.1447386 0.6326658  
Ride\_hailing 0.5603676 2.0167388  
 edu\_leveljunior high certificate  
Paratransit 0.07358847  
Private\_transport 0.02202311  
Ride\_hailing 0.26196497  
 edu\_levelno certificate and can not read  
Paratransit 3.185586e-02  
Private\_transport 2.784823e-02  
Ride\_hailing 2.479999e-10  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit 0.3203533 3.069632e+04  
Private\_transport 0.5128474 3.163238e-02  
Ride\_hailing 0.6329737 4.718399e-02  
 marital\_statusMarried marital\_statusseparated  
Paratransit 1.434550 1.944445e+06  
Private\_transport 6.224840 4.944569e-01  
Ride\_hailing 2.517689 2.312599e-01  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit 0.757753 0.4376642  
Private\_transport 1.636129 0.6749352  
Ride\_hailing 1.210654 0.8868770  
 employ\_statusStudent employ\_statusUnemployed  
Paratransit 0.22069913 0.2362659  
Private\_transport 0.04894052 0.1367848  
Ride\_hailing 0.99079161 0.3194933

## p-value

(Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 0.004106918 0 0.9626057  
Private\_transport 0.168622892 0 0.7857378  
Ride\_hailing 0.589050240 0 0.8412099

primary\_tripswork genderMale age25 - 30 years  
Paratransit 0.4887493 0.4749037 0.7401406  
Private\_transport 0.6483516 0.8848529 0.5069900  
Ride\_hailing 0.7131573 0.2182338 0.9378191  
 age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit 0.2294472 0.8214099 0.05791297  
Private\_transport 0.3452350 0.7534382 0.75752021  
Ride\_hailing 0.4635633 0.7238342 0.99932059  
 age61 and above ageunder 18 edu\_levelhigh school certififcate  
Paratransit 0 0.5508279 0.09626106  
Private\_transport 0 0.0000000 0.02267328  
Ride\_hailing 0 0.0000000 0.53029302  
 edu\_levelHND/diploma edu\_leveljunior high certificate  
Paratransit 0.9879504 0.0020599070  
Private\_transport 0.7155152 0.0004027995  
Ride\_hailing 0.6026476 0.2308599912  
 edu\_levelno certificate and can not read  
Paratransit 0.0003800785  
Private\_transport 0.0011103720  
Ride\_hailing 0.0000000000  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit 0.3719147 0  
Private\_transport 0.6144244 0  
Ride\_hailing 0.7663467 0  
 marital\_statusMarried marital\_statusseparated  
Paratransit 0.8054318 0  
Private\_transport 0.3062886 0  
Ride\_hailing 0.6233173 0  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit 0.8205352 0.3687722  
Private\_transport 0.7568539 0.6800013  
Ride\_hailing 0.9061651 0.9165420

employ\_statusStudent employ\_statusUnemployed  
Paratransit 0.110976160 0.1472194  
Private\_transport 0.004794651 0.0743715  
Ride\_hailing 0.993612671 0.3934254

# Accuracy the class on train dataset.

[1] 72.05

Our model accuracy has turned out to be 72.05% in the training dataset*.*

## Accuracy the class on test dataset.

[1] 73.42

We were able to achieve 73.42% accuracy in the test dataset and this number is very close to train (72.05%), and thus we conclude that the model is good and is also stable.

# Misclassification error

Non\_motorized\_transport Paratransit Private\_transport Ride\_hailing  
 Non\_motorized\_transport 2 1 0 0  
 Paratransit 20 263 54 24  
 Private\_transport 3 7 25 2  
 Ride\_hailing 0 0 0 0  
   
263 respondents were classified as Paratransiters and the model confirms that is true. However, 2 of them were classified as Ride\_hailing but the model says they are Private\_transporters. etc

# Misclassification Error Percentage

[1] 27.68

# @ during covid

## Model with Non-motorized transport as reference

weights: 96 (69 variable)  
initial value 555.904039   
iter 10 value 392.100795  
iter 20 value 362.886792  
iter 30 value 356.279358  
iter 40 value 354.585781  
iter 50 value 353.895460  
iter 60 value 353.753728  
iter 70 value 353.731051  
final value 353.728815   
converged

Call:  
multinom(formula = transport\_mode ~ primary\_trips + gender +   
 age + edu\_level + marital\_status + employ\_status, data = during)  
  
Coefficients:  
 (Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 19.35848 15.26917 0.6831858  
private transport. 19.46751 14.49447 0.4307361  
Ride hailing 17.39033 15.31997 1.2404601  
 primary\_tripswork genderMale age25 - 30 years  
Paratransit 2.297779 -1.163298 1.0658292  
private transport. 2.064615 -1.540170 0.3739856  
Ride hailing 2.926295 -2.224740 1.3003080  
 age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit -0.9522897 6.574390 7.052945  
private transport. -1.3443478 7.239509 8.281867  
Ride hailing -1.5687151 5.322238 7.747209  
 age61 and above ageunder 18  
Paratransit -41.132272 14.599333  
private transport. -5.720097 -9.856763  
Ride hailing -41.525387 14.449733  
 edu\_levelhigh school certififcate edu\_levelHND/diploma  
Paratransit 0.7514611 15.94034  
private transport. -0.6198960 15.35042  
Ride hailing 1.0721148 17.21886  
 edu\_leveljunior high certificate  
Paratransit -1.2415313  
private transport. -4.0104717  
Ride hailing -0.8817279  
 edu\_levelno certificate and can not read  
Paratransit -4.189514  
private transport. -5.568710  
Ride hailing -3.665049  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit 15.81451 11.58392  
private transport. 15.86872 12.92711  
Ride hailing 15.18152 -12.77344  
 marital\_statusMarried marital\_statusseparated  
Paratransit 1.689335 -9.983104  
private transport. 2.264696 -1.881623  
Ride hailing 2.180478 15.552591  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit 0.2626867 -16.04420  
private transport. 0.4172832 -15.22607  
Ride hailing 0.4561209 -15.44860  
 employ\_statusStudent employ\_statusUnemployed  
Paratransit -16.99068 -17.61773  
private transport. -18.15628 -17.62244  
Ride hailing -16.04368 -17.10803

Std. Errors:  
 (Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 2.908832 0.3630145 1.219806  
private transport. 2.999605 0.4793717 1.286555  
Ride hailing 2.963231 0.4905642 1.287269  
 primary\_tripswork genderMale age25 - 30 years  
Paratransit 1.297668 1.003419 1.336031  
private transport. 1.346860 1.031551 1.380530  
Ride hailing 1.353790 1.021007 1.361956  
 age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit 1.257843 135.4609 0.5428458  
private transport. 1.337286 135.4616 0.5425973  
Ride hailing 1.345346 135.4628 0.6378315  
 age61 and above ageunder 18  
Paratransit 3.098357e-09 0.4040639  
private transport. 3.610174e+00 NaN  
Ride hailing 5.242993e-13 0.4040639  
 edu\_levelhigh school certififcate edu\_levelHND/diploma  
Paratransit 1.470456 0.2324697  
private transport. 1.513366 0.2941654  
Ride hailing 1.493698 0.2789587  
 edu\_leveljunior high certificate  
Paratransit 1.758586  
private transport. 1.927273  
Ride hailing 1.793938  
 edu\_levelno certificate and can not read  
Paratransit 1.695167  
private transport. 1.796259  
Ride hailing 1.730747  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit 0.3466160 8.221934e-01  
private transport. 0.3953459 8.221934e-01  
Ride hailing 0.5524306 8.103698e-11  
 marital\_statusMarried marital\_statusseparated  
Paratransit 3.865294 3.151713e-09  
private transport. 3.938447 8.139301e-08  
Ride hailing 3.902107 1.273927e-05  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit 3.642612 1.472163  
private transport. 3.712872 1.489402  
Ride hailing 3.673673 1.486421  
 employ\_statusStudent employ\_statusUnemployed  
Paratransit 1.168552 1.220432  
private transport. 1.218383 1.267948  
Ride hailing 1.191983 1.255806  
  
Residual Deviance: 707.4576   
AIC: 845.4576

# Odds Ratios

(Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 255434538 4278735 1.980176  
private transport. 284859268 1971832 1.538390  
Ride hailing 35688267 4501704 3.457204  
 primary\_tripswork genderMale age25 - 30 years  
Paratransit 9.952056 0.3124539 2.903245  
private transport. 7.882262 0.2143447 1.453516  
Ride hailing 18.658373 0.1080955 3.670427  
 age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit 0.3858565 716.5085 1156.259  
private transport. 0.2607097 1393.4094 3951.564  
Ride hailing 0.2083127 204.8418 2315.102  
 age61 and above ageunder 18  
Paratransit 1.369245e-18 2.189826e+06  
private transport. 3.279394e-03 5.239165e-05  
Ride hailing 9.241735e-19 1.885555e+06  
 edu\_levelhigh school certififcate edu\_levelHND/diploma  
Paratransit 2.1200954 8371448  
private transport. 0.5380004 4640884  
Ride hailing 2.9215513 30064771  
 edu\_leveljunior high certificate  
Paratransit 0.28894143  
private transport. 0.01812484  
Ride hailing 0.41406683  
 edu\_levelno certificate and can not read  
Paratransit 0.015153646  
private transport. 0.003815401  
Ride hailing 0.025602927  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit 7381668 1.073574e+05  
private transport. 7792861 4.113124e+05  
Ride hailing 3919687 2.835077e-06  
 marital\_statusMarried marital\_statusseparated  
Paratransit 5.415880 4.617352e-05  
private transport. 9.628196 1.523426e-01  
Ride hailing 8.850539 5.680733e+06  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit 1.300419 1.076698e-07  
private transport. 1.517832 2.440069e-07  
Ride hailing 1.577941 1.953251e-07  
 employ\_statusStudent employ\_statusUnemployed  
Paratransit 4.178715e-08 2.232126e-08  
private transport. 1.302653e-08 2.221632e-08  
Ride hailing 1.077256e-07 3.716012e-08

## p-value

(Intercept) primary\_tripsshopping primary\_tripsstudy  
Paratransit 2.831668e-11 0 0.5754265  
private transport. 8.582357e-11 0 0.7377774  
Ride hailing 4.392060e-09 0 0.3352280  
 primary\_tripswork genderMale age25 - 30 years  
Paratransit 0.07661085 0.24631975 0.4250110  
private transport. 0.12529808 0.13542077 0.7864680  
Ride hailing 0.03065233 0.02933409 0.3397114

age31 - 40 years age41 - 50 years age51 - 60 years  
Paratransit 0.4490009 0.9612911 0  
private transport. 0.3147616 0.9573787 0  
Ride hailing 0.2436021 0.9686597 0  
 age61 and above ageunder 18  
Paratransit 0.000000 0  
private transport. 0.113094 NaN  
Ride hailing 0.000000 0  
 edu\_levelhigh school certififcate edu\_levelHND/diploma  
Paratransit 0.6093235 0  
private transport. 0.6820891 0  
Ride hailing 0.4729061 0  
 edu\_leveljunior high certificate  
Paratransit 0.48019898  
private transport. 0.03744264  
Ride hailing 0.62306986  
 edu\_levelno certificate and can not read  
Paratransit 0.013456769  
private transport. 0.001934087  
Ride hailing 0.034208046  
 edu\_levelpostgraduate marital\_statusDivorced  
Paratransit 0 0  
private transport. 0 0  
Ride hailing 0 0  
 marital\_statusMarried marital\_statusseparated  
Paratransit 0.6620734 0  
private transport. 0.5652761 0  
Ride hailing 0.5763016 0  
 marital\_statusSingle employ\_statusSelf Employed  
Paratransit 0.9425105 0  
private transport. 0.9105156 0  
Ride hailing 0.9011891 0

employ\_statusStudent employ\_statusUnemployed  
Paratransit 0 0  
private transport. 0 0  
Ride hailing 0 0

# Accuracy of the class on train dataset

[1] 61.6

Our model accuracy has turned out to be 61.6% in the training dataset*.*

## Accuracy of the class on test dataset.

[1] 63.29

We were able to achieve 63.29% accuracy in the test dataset and this number is very close to train (61.6%), and thus we conclude that the model is good and is also stable.

# Misclassification error

Non-motorized transport Paratransit private transport Ride hailing  
 Non-motorized transport 5 2 0 0  
 Paratransit 6 181 51 55  
 private transport. 0 10 30 4  
 Ride hailing 0 19 7 31  
   
181 respondents were classified as Paratransiters, and the model confirms that is true. However, 2 of them were classified as Paratransiters but the model says they are Non motorized transporters.

# Misclassification Error Percentage

[1] 38.4