independent variables, in order to explain the variability more comprehensively.

Finally, the slope and intercept model is run to test the interaction between the predictor variables of level1 and level2. The inter-level effects of the variables were tested inclusively. In brief, the slope and intercept model could be used to test the two models discussed earlier, instead of evaluating them separately, but there will be variation in the obtained results, since the maximum likelihood estimation methods will vary. The slope and intercept model revealed the significance of different variables in terms of their fixed effects. This result is displayed in table 5 below:

The table 5 demonstrates the results for only those fixed effects which showed significant coefficient values. In the drilling installation, the main effects of Contact on Accidents is significant. i.e. ($\beta_s = 3.75, t = 0.348$). That is, the grand mean of Accidents increases or decreases by 3.75 units with 1 unit increase or decrease in Contact. This concept applies in a similar manner to the rest of the other fixed effects. The main effects of different significant variable can be compared across the four installations with the help of figure 2.

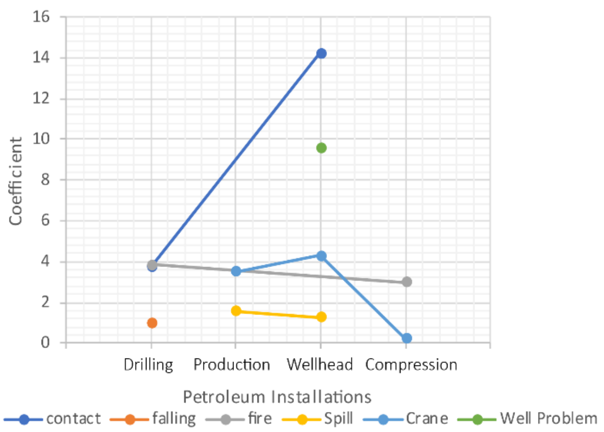

Figure 2. Comparison of main effects of different predictor variables by slope and intercept model

In figure 2, the comparison of different variables could be done by visual inspection. From the figure, the main effects of crane variable is seen prevalent in three installations, namely, production, wellhead and compression, whereas in wellhead installation, contact variable has the most significant value of coefficient $(\beta_s) = 14.22285, t = 2.02$. It can be concluded that all the activities involved with crane operations are more exposed to accidents in three of the installations, but the activities associated with contact variable are anticipated to have more dire consequences due to their higher coefficient values.

4. RESULTS

Since the analyses are complete, it is now possible to summarize the results. Hierarchical linear modelling (HLM) is used to statistically analyze a data structure where different hazardous parameters (level-2) are nested within the level-1 predictor variables comprising of the number of accidents occurred and the observed installations in each subsequent year. The relationship between the multilevel predictor variables were of specific interest throughout the study. Model testing progressed in 4 phases: unconditional model, random intercepts model, mean outcome model and intercept & slope model.

The ICC of the unconditional model resulted .20. Therefore, 20% of the variance in Accidents is between-group level and 80% of variance between level-1 variables. Since, at each level, the variance had existed, it is required to add each predictor variable separately. The random intercept model was tested using the no. of observed installations each year, as predictor variable. It could be inferred that the accidents were seen prevalent in the years when the number of observed installations were also higher. It revealed that results obtained while considering the afore-mentioned level-1 predictor variable was insufficient to explain the variance in the outcome variable and henceforth, provide justification for the further endeavors. In means as outcomes model, the predictor variables at level-2 were added which explained that those variables which were significant, greatly influenced the value of outcome variable. The slope and intercept model was run in the last to test the simultaneous interaction of predictor variables with the outcome variable. The cross-level interaction demonstrated significant results revealing the main effects of the predictor variables across the installations. It is clearly understood from the figure 2, that the crane variable is seen prevalent throughout three installations type and contact variable had the most significant value in wellhead installations. Through this conception, we can further derive the vulnerability of other significant predictor variables that have influential effects on the hazardous accidents in different installations. The approach applied throughout the research provided a different perception of the hazards involved in the OG industry which significantly indicated the areas of vulnerabilities which could not have been obtained from a conventional perspective.

5. CONCLUSION

The present research has demonstrated that the present hierarchical modelling methodology applied for risk appraisal provide pluralistic approach towards optimized decisions resulting in the increased preparedness of infrastructural components in OG industry from unforeseen hazards. It is envisaged that the research has also provided a framework which will form an important module in prioritizing components of substantial hazards on different petroleum installations.

REFERENCES

[1] Oracle White Paper - How to Reduce Costs and Manage Risk in the Upstream Oil & Gas Industry with Enterprise Project and Portfolio Management Solutions (2011). Oracle Corporation, California, USA.

[2] Tirmizi S.T., Tirmizi S.R.U.H. (2017). GIS based risk assessment of oil and gas infrastructure in Sindh, Pakistan, *Environmental and Earth Sciences Research Journal*, Vol. 4, No. 3, pp. 55-59. DOI: 10.18280/eesrj.040301

[3] Funnemark E., Young E. (2003). Accident statistics for fixed offshore units on the UK Continental Shelf 1980-2001, Health and Safety Executive, Hovik, Norway.

[4] McMahon S.M., Diez J.M. (2007). Scales of association: hierarchical linear models and the measurement of ecological systems, Vol. 10, No. 6, pp. 437-452. DOI: 10.1111/j.1461-0248.2007.01036.x

[5] Johnson B., Multilevel analysis in the study of crime and justice, Handbook of Quantitative Criminology, Piquero A. R., Weisburd D. L., Springer, New York, pp. 615-648. DOI: 10.1007/978-0-387-77650-7_30

[6] Osborne J.W. (2000). Advantages of Hierarchical Linear Modelling, *Practical Assessment, Research & Evaluation*, Vol. 7, No. 1.