RISK MANAGEMENT AND DATA ANALYTICS USING DIGITAL TECHNOLOGY

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Introduction

- It is estimated that approximately 374 million occupational injuries, 2.78 million work related fatalities (of which 2.4 million are disease-related) occur each year in the world from a total population of 3 billion workforce.

- It is well known that the mining industry is an inherently hazardous industry.

- The mining industry has one of the highest injury rates among the major industry divisions

- Occupational injuries and diseases result in severe socio-economical consequences for workers and the society

Introduction (cont.)

- Mining accounts for about 1% of the worlds workforce (ILO, 34th ICSMRI, 2011). According to ILO's estimate around 30 million people work in mines, of whom about 10 million are involved in coal production. Although accounting for about 1% of the global workforce, it is responsible for about 8% of fatal accidents at work.
- The occurrences of injuries and diseases in mines depend upon many complex factors such as physical, individual, and social factors, which highly vary from individual to individual and from situation to situation.
- Everyday the miners are exposed to several job related hazards such as heat, noise, dust, vibration, and machine-related hazards which certainly impose additional stresses upon the workers.

Introduction (cont.)

- Compliance to prescriptive regulations is a prerequisite, but is not sufficient to achieve prevention

- The field of health and safety engineering should be widely practised in the Indian Mining Industry as a self regulatory measure

- The areas that need attention in health and safety engineering are risk management, health and safety data analytics, human factors, behavioural based safety and health issues.

Table: Fatality rates per 1000 persons Employed in Coal and Non Coal Mines In India (1951-2014)

Decade	Coal mines	Non coal mines
1951 -60	0.82	0.34
1961-70	0.62	0.33
1971-80	0.55	0.30
1981-90	0.34	0.31
1991-2000	0.33	0.36
2001-2010	0.27	0.40
2011-2017	0.21	0.25

- The fatality rate per 1000 persons employed in Indian Non-Coal Mines is 0.40 during the period 2001-10 where as for Coal Mines 0.27 respectively in the same year.

Source: DGMS ANNUAL REPORT 2015

HEALTH AND SAFETY PRACTICES IN MINES: PAST, PRESENT AND FUTURE

Past	Present and Future
Mostly prescriptive regulation is followed. Workers' safety is solely a function of training, procedures, policy and chance	Pro-active self regulatory measures are to be followed. New smart programs and technologies, such as location awareness technologies, GPS, RFIDs and collision detection/avoidance improve the safety of each employee both during daily routines and during incidents. Virtual reality based safety training is to be implemented
Access, privileges, status and the management of employees is delegated to immediate supervisor and informal processes	Companies deploy sophisticated and automated Identity and Security Management programs that systematically and centrally track employees' access rights, location, duration, training, safety certification, permissions, compliance and site security
Mostly classification based accident data analysis is followed to identify accident trends and pattern	Huge safety related data collected through various sources should be analyzed through safety analytics to improve health and safety of mine workers.

Modified after IBM: White Paper (2009)

RISK MANAGEMENT AND ANALYIS:

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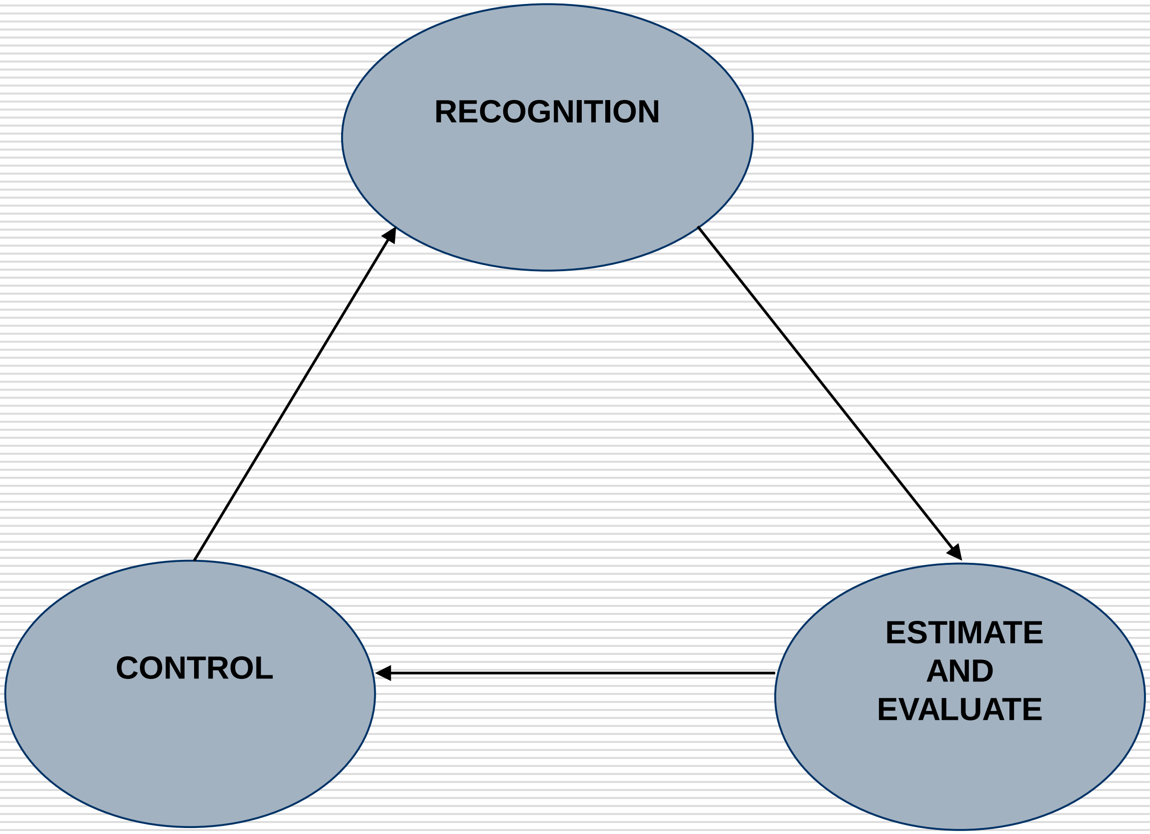
Risk Management

- It is a process by which management decisions are made about controlling and minimizing hazards and accepting residual risks.

Risk Analysis

- It is a process for evaluating potential risks (Realization of unwanted consequences) associated with particular activities.

CONCEPT OF RISK MANAGEMENT:



HEALTH AND SAFETY DATA ANALYTICS:

HEALTH AND SAFETY DATA ANALYTICS:

- It applies two very powerful statistical techniques
  - Data mining

    It models relevant previous data

    - Traditional/visible/direct/conventional risk characteristic data
    - Non-traditional/not visible/indirect/unconventional data

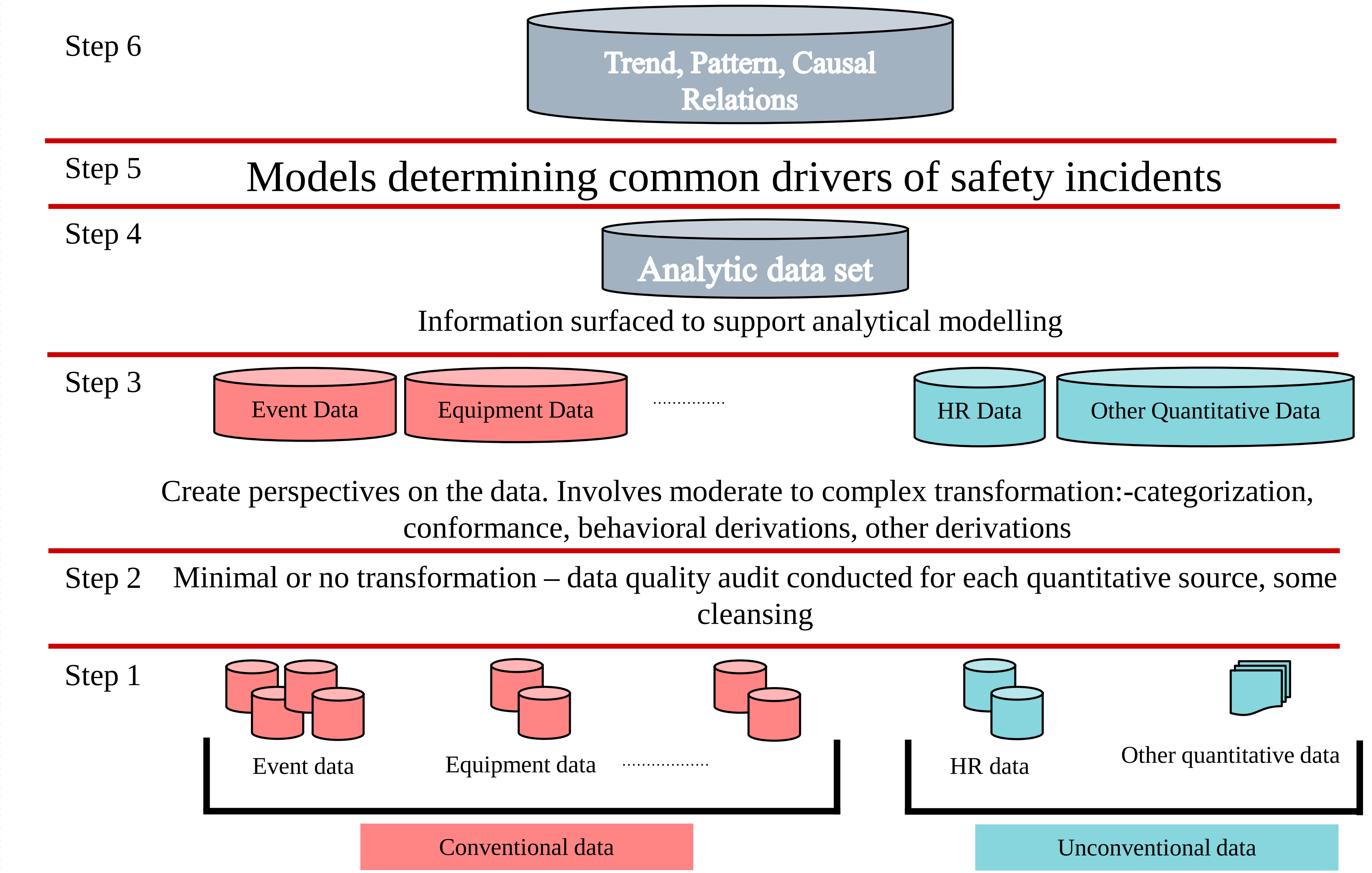
  - Trend, Pattern, and relationship of causal factors
    - Correlation analysis
    - Regression analysis

NEED OF HEALTH AND SAFETY DATA ANALYTICS:

- In todays mining industry due to automation of mining operations, a huge amount of data, directly or indirectly related to health and safety, are being generated and collected. It is difficult to handle such big data manually.

- Though data are available, not enough analysis is being done to create meaningful information to assist in decision making process related to enhancement of safety in mines.

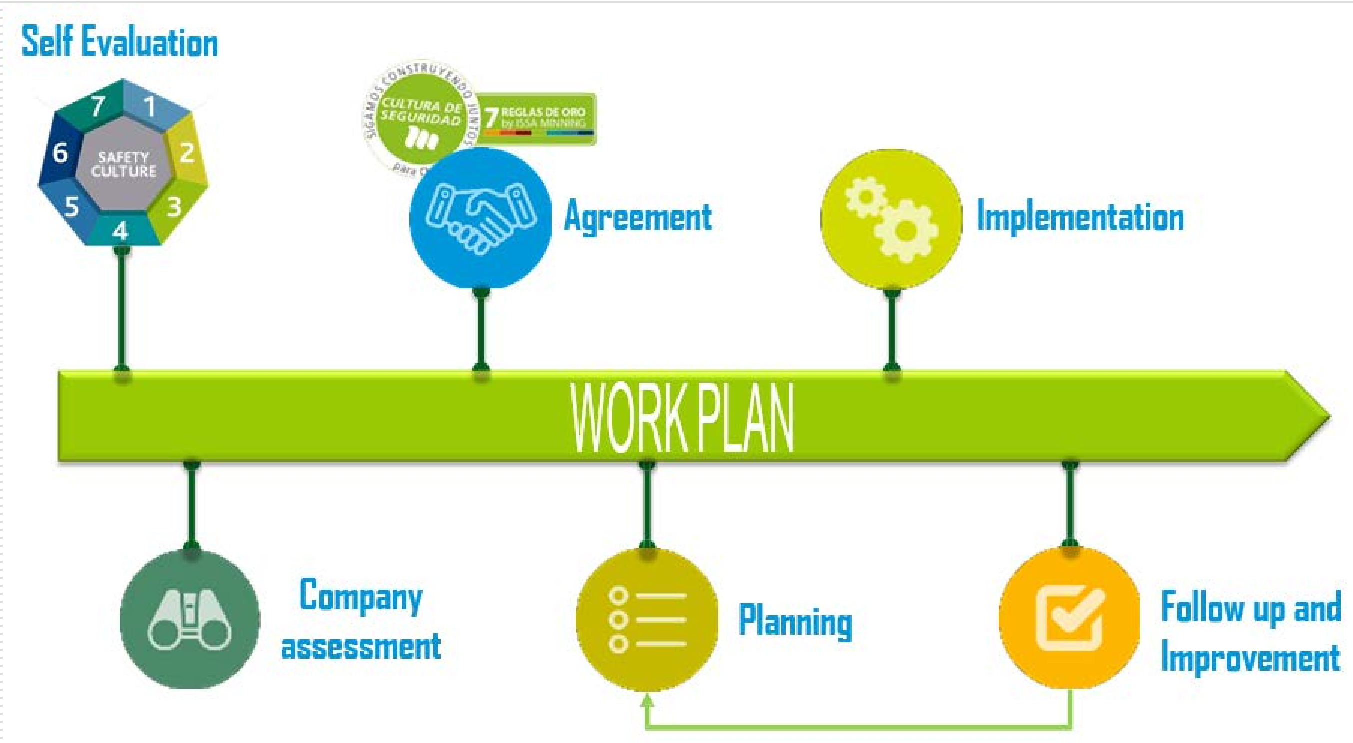
HEALTH AND SAFETY DATA ANALYTICS APPROACH:



INTEGRATION OF RISK MANAGEMENT AND SAFETY DATA ANALYTICS USING DIGITAL TECHNOLOGY:

Trend/Pattern Recognition - Knowledge Building - Decision Making

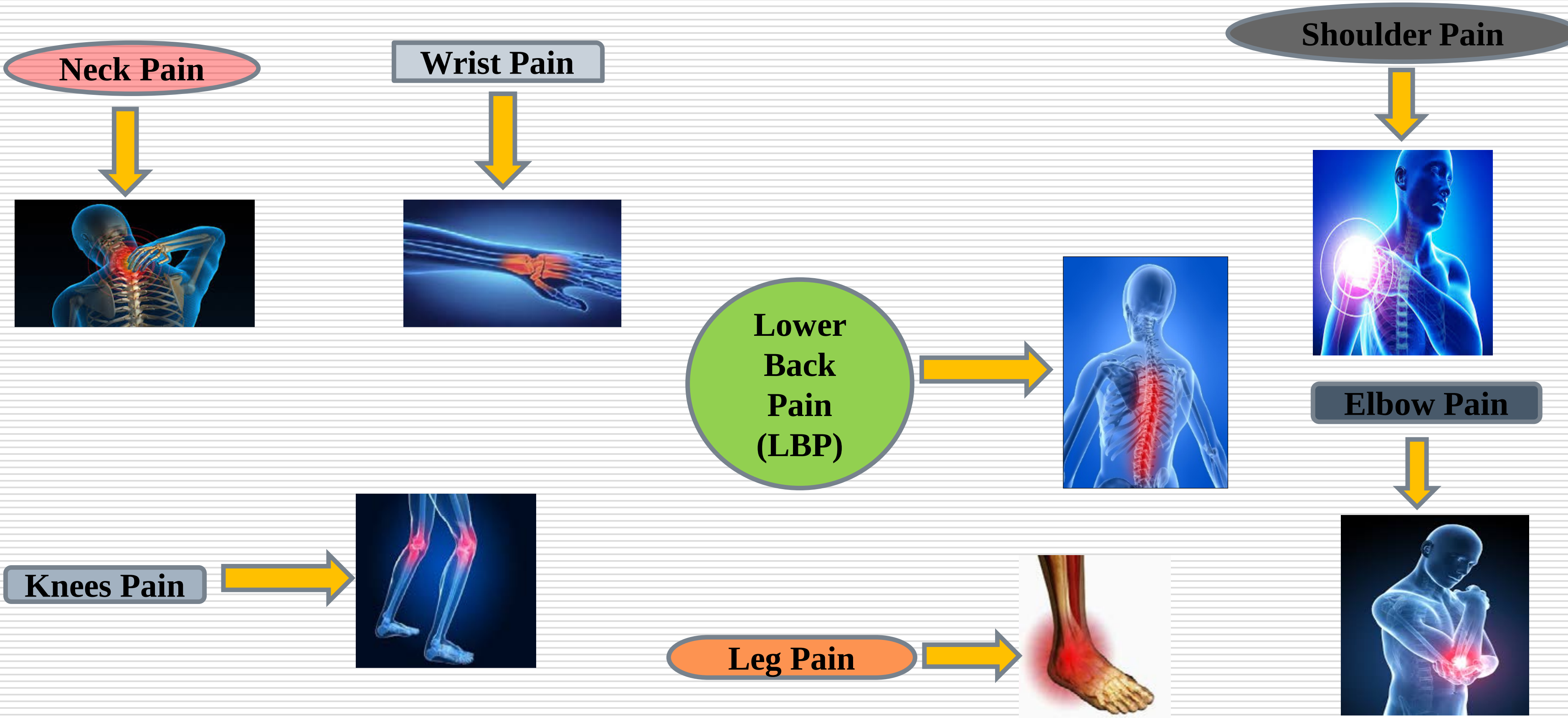
PROCESS OF IMPLEMENTATION OF SELF EVALUATION APPROACHES:



Source: ISSA Mining

APPLICATION OF HEALTH DATA ANALYTICS IN WHOLE-BODY VIBRATION EXPSOURE ASSESSMENT

MUSCULOSKELETAL DISORDERS PROBLEMS FROM WBV TO DUMPER OPERATORS IN MINES



DGMS RECOMMENDATION:-11th NATIONAL SAFETY CONFERENCE, 2013, NEW DELHI

In the 11th Conference on Safety in Mines which was held in New Delhi, 2013, Directorate General of Mines Safety (DGMS) have recommended that:

Vibration studies of various mining machineries before their introduction in mining operation should be done as per ISO standards.

Ergonomic assessment of all latest machines, before their introduction into mining operation which includes:

- Assessment of work process
- Assessment of working aids/tools
- Assessment of working posture

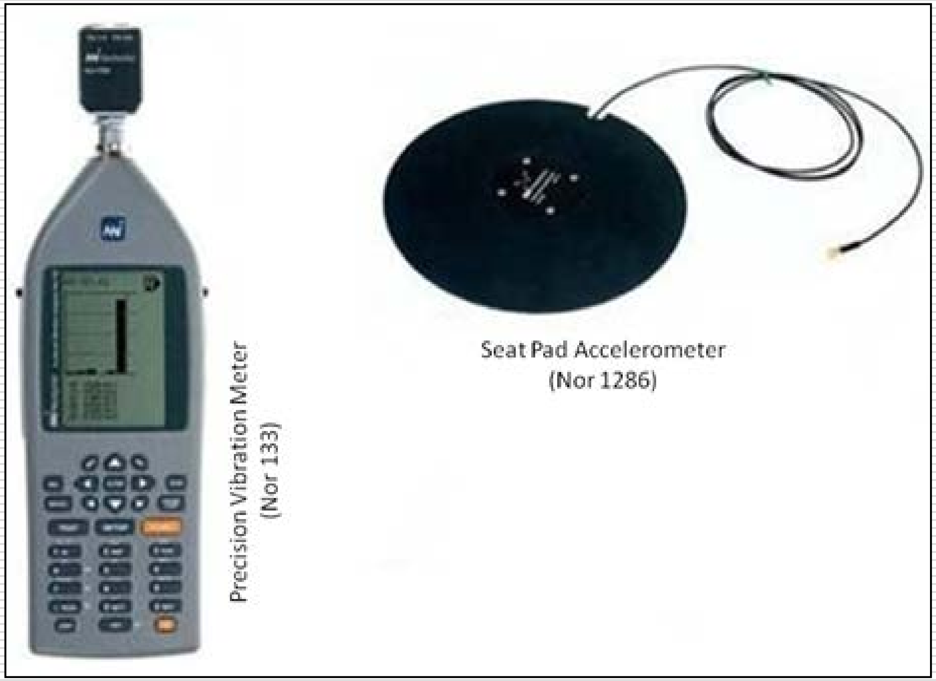
Summary of vibration exposure limits and guidelines for 8 – hour duration ISO-2631-1:1997/Amendment:2010

Assessment of Health Risks	Predicted Health Risks	RMS acceleration, A(8), m s^{-2}	Vibration dose value, VDV(8), m $s^{-1.75}$
"For exposures below the health guidance caution zone, health effects have not been clearly documented"	Low	<0.45	<8.5
"…in the health guidance caution zone, potential health risks is indicated"	Moderate	0.45-0.90	8.5-17
"…above the health guidance caution zone, health risks are likely"	High	>0.9	>17

Eger et al., 2008

MEASURING WHOLE-BODY VIBRATION

WBV is measured in accordance with ISO 2631-1: 1997/Amendment:2010



Seat pad accelerometer and Precision vibration meter

HEMM EQUIPMENT STUDIED

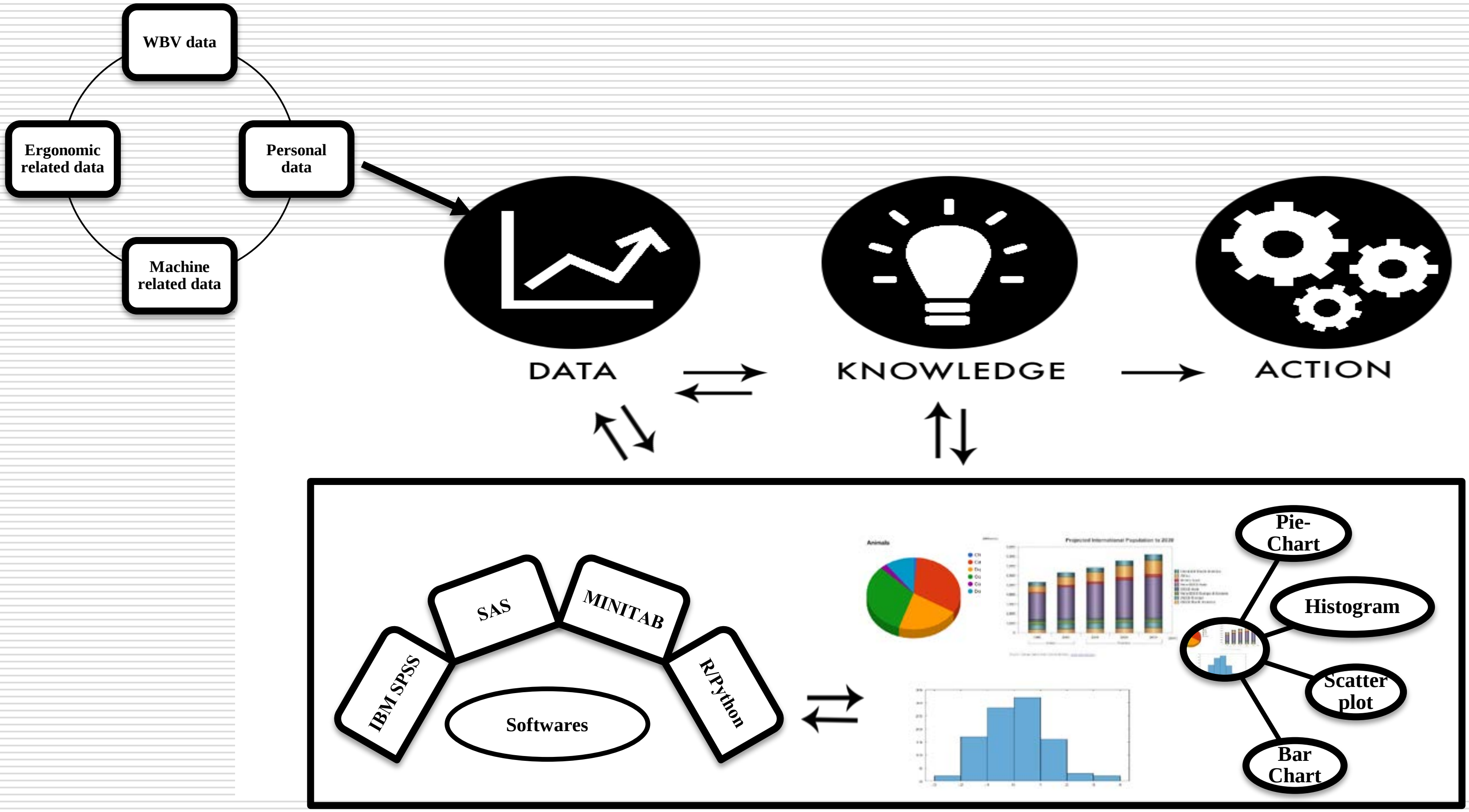
HEMM Operators

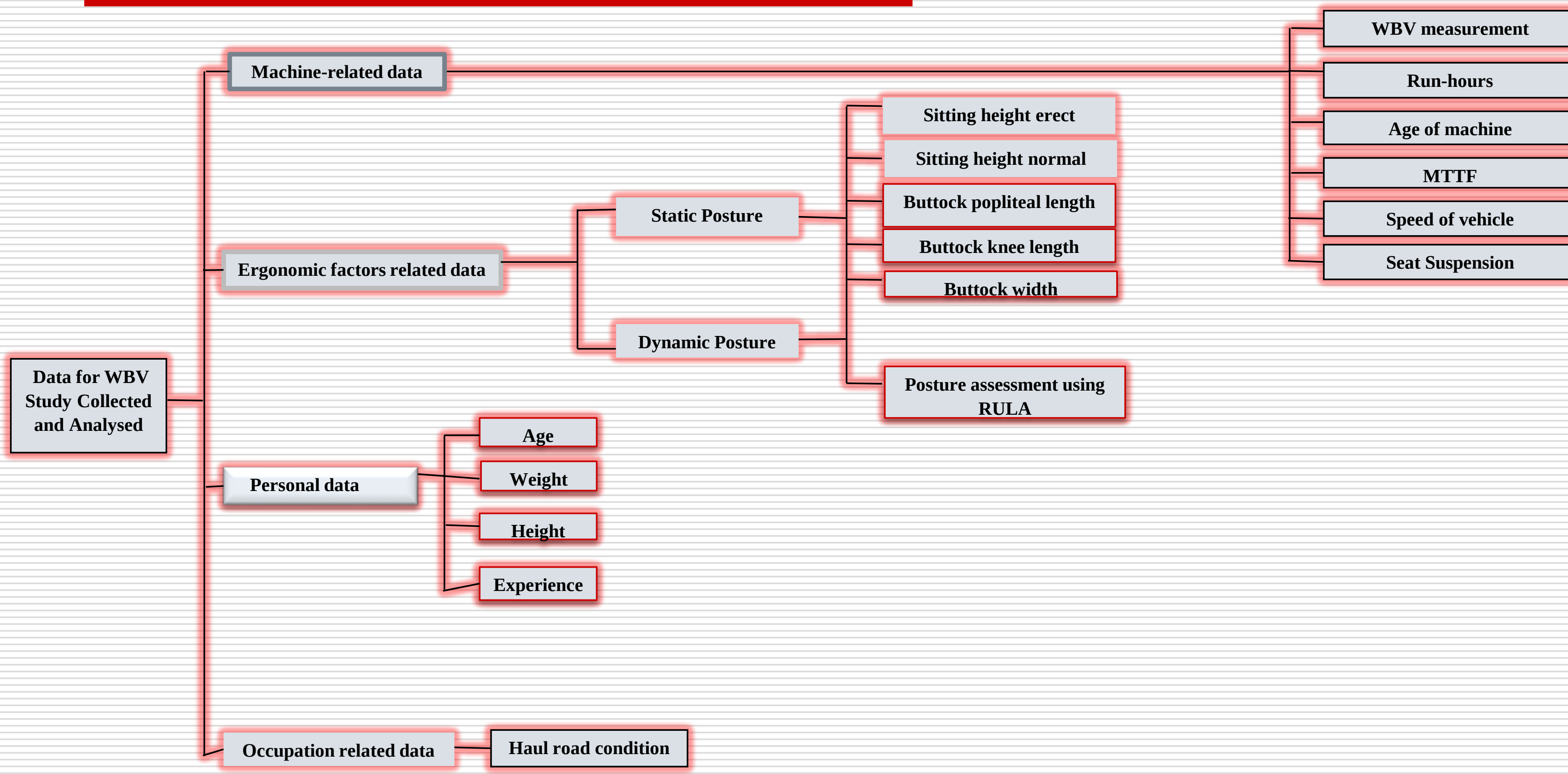
Dumper Operators in an Iron Ore Mine

POORLY DESIGNED SEATS OF DUMPER OPERATORS IN MINES

Dumper Operators

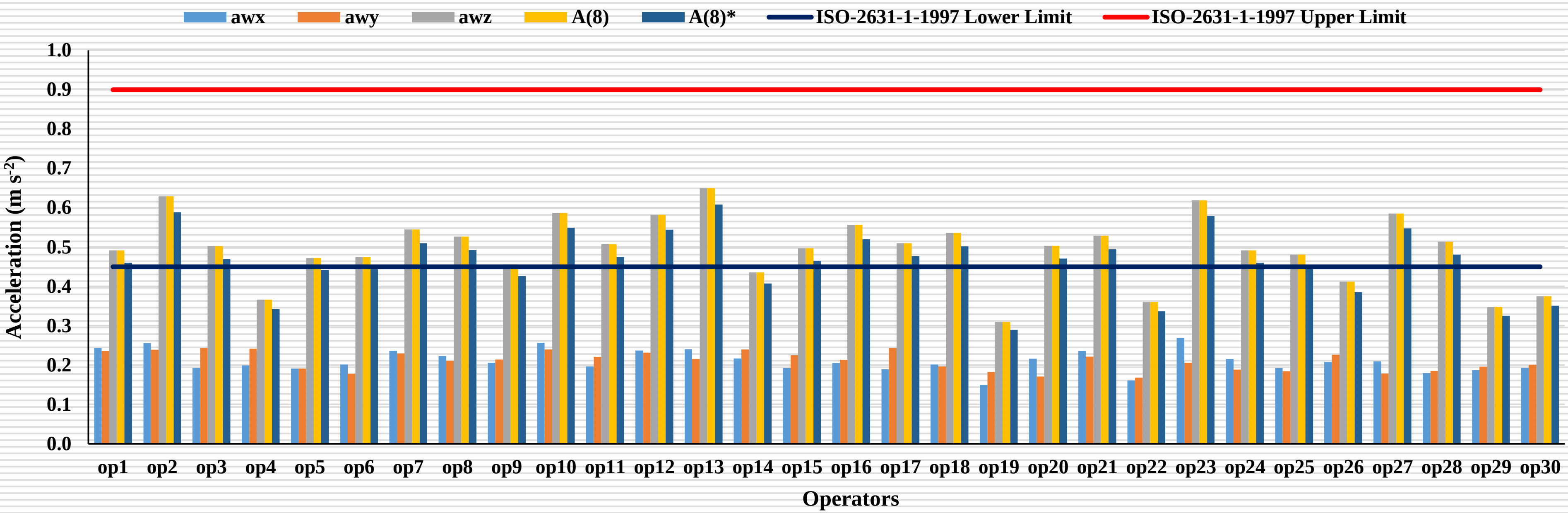
Health Related Data Analytics- Knowledge Building - Decision Making using Digital Technology



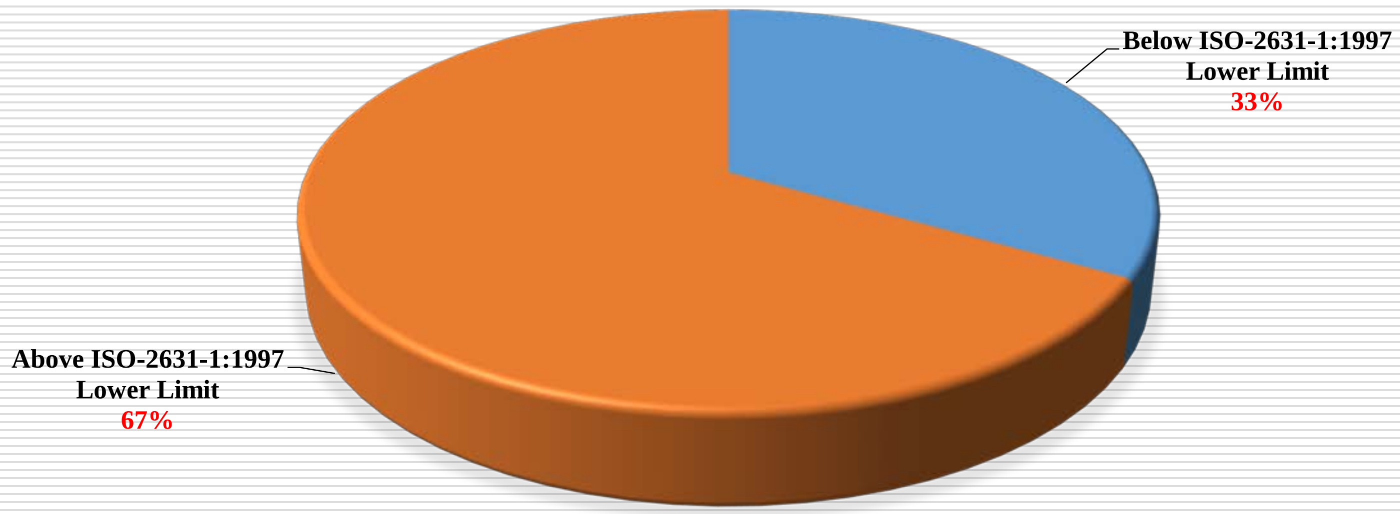


Data for WBV Study Collected and Analysed
Machine-related data
WBV measurement
Run-hours
Age of machine
MTTF
Speed of vehicle
Seat Suspension
Ergonomic factors related data
Static Posture
Dynamic Posture
Sitting height erect
Sitting height normal
Buttock popliteal length
Buttock knee length
Buttock width
Posture assessment using RULA
Personal data
Age
Weight
Height
Experience
Occupation related data
Haul road condition

Frequency-Weighted RMS Acceleration

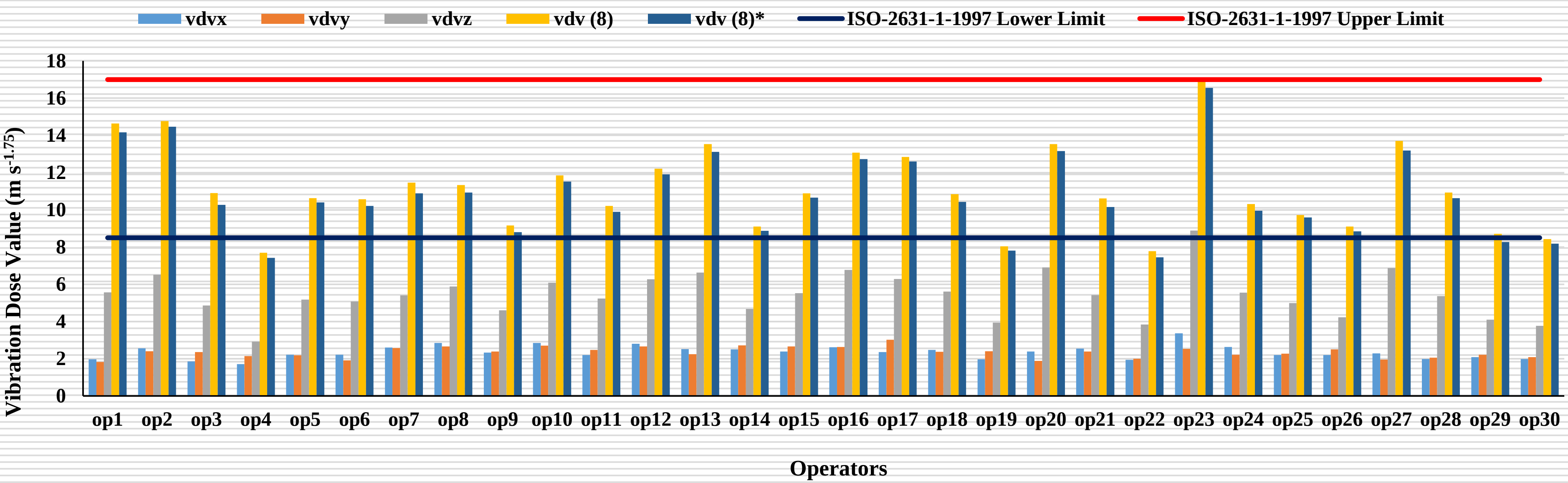


A(8)*: 7 hrs exposure in an 8 hrs shift

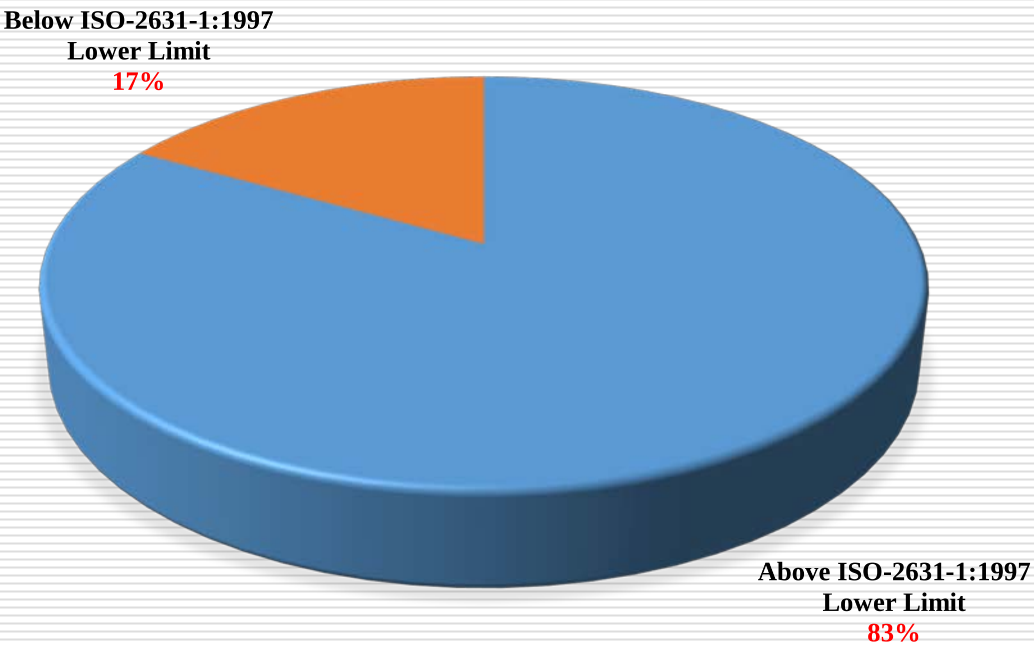


Frequency-weighted RMS Acceleration

Vibration Dose Value (VDV)



VDV(8)*: 7 hrs exposure in an 8 hrs shift



Vibration Dose Value (VDV)

Crest Factors

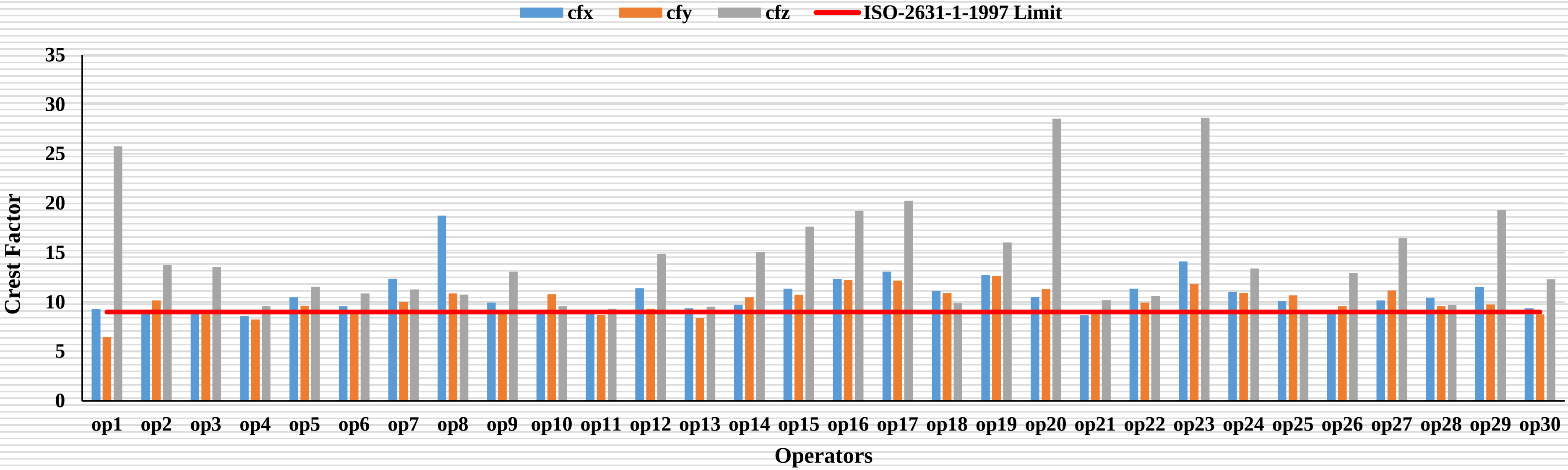
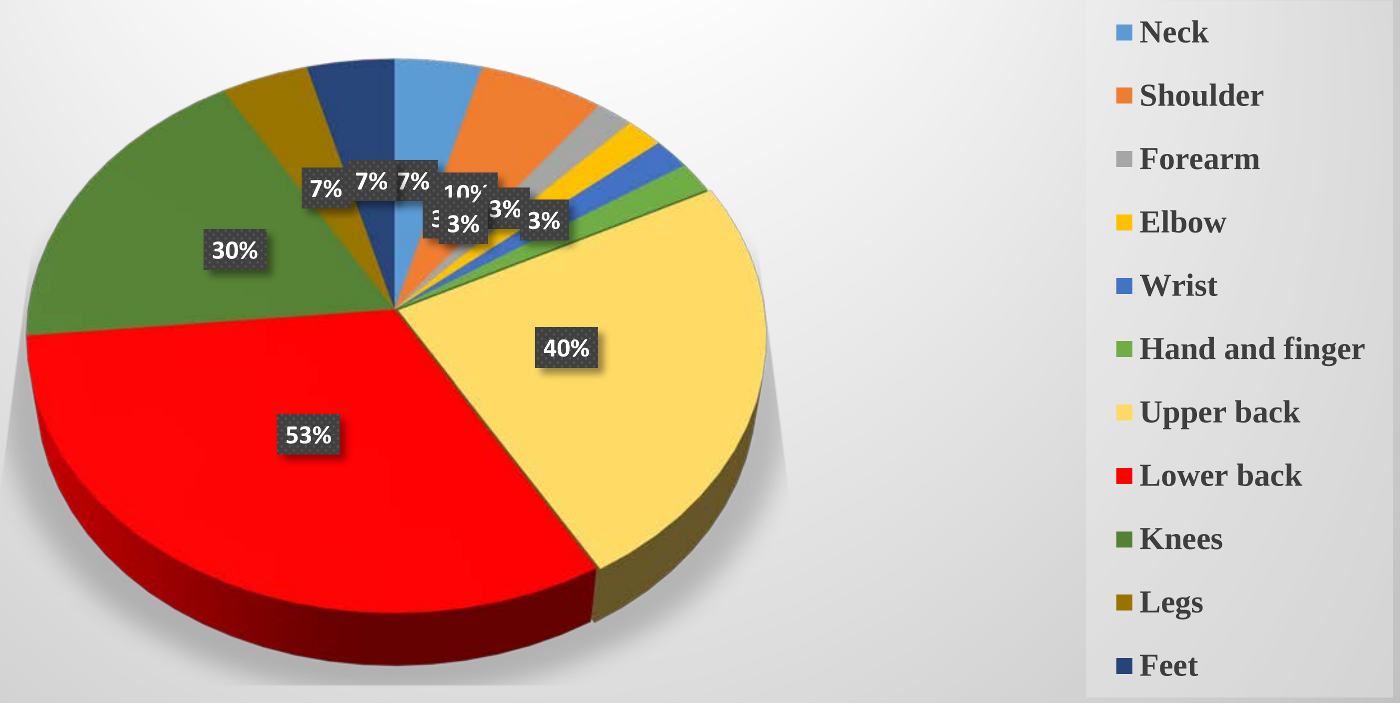


Table 1. MEAN AND RANGE OF PARAMETERS FOR THE DUMPER OPERATORS (SAMPLE SIZE=30)

Parameters	Mean	% of values below the lower limit of ISO 2631-1: 1997	% of values between upper and lower limit of ISO 2631-1: 1997	% of values above the upper limit of ISO 2631-1: 1997
Frequency-weighted RMS Acceleration (m s^{-2})		< 0.45 m/s^2	0.45 - 0.90 m/s^2	> 0.9 m/s^2
x-axis (a_{wx})	0.210	100	0	0
y-axis (a_{wy})	0.211	100	0	0
z-axis (a_{wz})	0.495	23.33	76.67	0
Daily RMS exposure, A(8)*, 7 hrs. exposure	0.463	33.33	66.67	0
Vibration Dose Value (m $s^{-1.75}$)		< 8.5 $m/s^{1.75}$	8.5 – 17 $m/s^{1.75}$	> 17 $m/s^{1.75}$
x-axis (VDV_x)	2.356	100	0	0
y-axis (VDV_y)	2.353	100	0	0
z-axis (VDV_z)	5.433	96.67	3.33	0
Daily VDV Value, *VDV*(8)*, 7 hrs. exposure	10.758	16.67	83.33	0
Crest Factor		< 9.0		> 9.0
CFx	10.730	16.67		83.33
CFy	10.032	23.33		76.67s
CFz	14.418	0		100

Musculoskeletal disorders among dumper operators (response of operators, n=30)



MSD problems of dumper operators (cases) and office workers (controls) in iron ore mines (30 pairs)

	Cases (n=30) %	Controls (n=30) %	P value
Musculoskeletal disorders [a]			
Neck pain	6.7	3.3	0.554
Shoulder pain	10.0	6.7	0.640
Upper back pain	40.0	13.3	***0.020****
Lower back pain	53.3	30.0	***0.017****
Knee pain	30.0	3.3	***0.006****
Leg pain	3.3	3.3	1.000

Cases: dumper operators in iron ore mines, controls: mine office workers in the same mines matched for age.
[a] based on the NIOSH Nordic musculoskeletal questionnaire (NMQ).
*p<0.05, **p<0.01.

RESULTS

In general, it was observed that the frequency weighted RMS acceleration based on daily exposure of 8 hours exceeded the lower limit of ISO 2631-1 (1997) (0.45 m s^{-2}) for 67% of the dumper operators, which indicate that the operators driving these machines are at moderate health risk. Therefore, these operators carry the risk of adverse health effect, especially MSD problems due to WBV exposure at the workplace and it requires management intervention to reduce the risk below the lower limit.

For almost all the dumper operators crest factor exceeded 9, indicating that the shock components are present for all the dumper operators. The daily vibration dose, VDV (8), exceed the lower limit (8.5 m $s^{-1.75}$) for 83% of the dumper operators, indicating that all the operators are at moderate health risk. The WBV exposure measurements revealed that the operators who participated in this study are at low, moderate or high risk from the WBV exposure.

Various factors identified based on our study that effects the WBV of dumper operators are tonnage, tyre pressure, haul road condition, poor posture and poorly design seat of the operators.

Conclusions and Recommendations – WBV Study

General Recommendation

Based on DGMS recommendation and various study conducted by the research team of IIT Kharagpur in different mines, all mines should carry out the vibration study to assess the health risk of operators. Moreover, all machines must be tested for vibration exposure so that they do not exceed the lower limit of ISO 2631-1:1997

Mine Specific Recommendation

The vibration exposure time of those operators should be reduced, who are exceeding the lower limit of vibration exposure, and

Machine parameters as well as other parameters that influence the WBV exposure should be explored through ergonomic process assessment.

Recommendations – WBV Study

Field Study Recommendations

From the vibration exposure study, most of the dumper operators were found to be in the medium to high risk zone which requires for an immediate action.

This field study leads to the ergonomic process assessment which will focus on anthropometry study which includes static and dynamic posture analysis as well as assessment of safe operating procedures.

THANK YOU