CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

The World Health Organization estimates occupational health risks as one of the leading cause of morbidity and mortality. The burden of disease from selected occupational risk factors amounts to 1.5% of the global burden in terms of DALY (Disability Adjusted Life Years). Occupational diseases cause huge suffering and losses to workers, businesses, social security funds and societies at large. According to International labour organisation (2013) estimates, diseases caused by work kill six times more workers than work-related accidents. It is estimated that there are globally about 2.02 million deaths annually caused by disease due to work (ILO 2011), while the annual global number of cases of non-fatal work-related disease is estimated to be 160 million. In addition to causing immeasurable human suffering to victims and their families, such diseases entail major economic losses for enterprises and societies as a whole, such as lost productivity and reduced work capacity. Globally, the International Labour Organisation (2013) estimates that around 4 per cent of the world’s gross domestic product (GDP), or about 2.8 trillion dollars, is lost owing to work-related accidents and diseases in direct and indirect costs.

India has a growing economy, the world’s most vibrant and largest democracy and an aspiring super power. India’s population has crossed 1.21 billion according to census report of 2011. Of these, 833 billion reside in rural
area and 377 million reside in urban areas. Those in working age group are estimated to be 63.6%. More than 90% work in the informal economy, mainly agriculture and services, (60% self-employed and 30% without regular jobs. Less than 10% have jobs in the organized sector; mainly industry, mining and some services. Major occupational risks are accidents, pneumoconiosis (especially silicosis), musculoskeletal disorders, chronic obstructive lung diseases, pesticide poisoning, byssinosis, asbestosis; noise induced hearing loss and workplace stress.

1.2 WORK RELATED MUSCULOSKELETAL DISORDERS

Musculoskeletal disorders (MSDs) were recognized as having occupational etiologic factors as early as the beginning of the 18th century. However, it was not until the 1970's that occupational factors were examined using epidemiologic methods, and the work-relatedness of these conditions began appearing regularly in the international scientific literature. The term musculoskeletal disorder denotes health problems of the locomotor apparatus, i.e. muscles, joints, tendons, the skeleton, cartilage, the vascular system, ligaments, nerves and the localised blood circulation system.

Work-related musculoskeletal disorders (WMSDs) include all MSDs that are induced or aggravated primarily by work and the circumstances of its performance. Most WMSDs are cumulative disorders, mainly affect the back, neck, shoulders and upper limbs, but can also affect the lower limbs.

Work related musculoskeletal disorders progress in stages from mild to severe.
- Early stage: Aching and tiredness of the affected limb occur during the work shift but disappear at night and during days of work and there is no reduction of work performance.

- Intermediate stage: Aching and tiredness occur early in the work shift and persist at night. There is reduced capacity for repetitive work.

- Late stage: Aching, fatigue and weakness persist at rest. There is also inability to sleep and to perform light duties.

Not everyone goes through these stages in the same way. In fact, it may be difficult to say exactly when one stage ends and the next begins. The first pain is a signal that the muscles and tendons should rest and recover. Otherwise, an injury can become longstanding and sometimes, irreversible. The earlier the people recognize symptoms, the quicker they should respond to them.

Nearly 1 million people each year report taking time away from work to treat and recover from musculoskeletal pain or loss of function due to overexertion or repetitive motion either in the low back or upper extremities (Bureau of Labor Statistics 1999). Although there is a risk of long-term disability in both types of disorder, the majority of individuals return to work within 31 days. Estimated workers' compensation costs associated with these
Several studies suggest that many disorders that could be attributed to work are not reported and therefore are not counted in any of the existing databases.

1.3 MUSCULOSKELETAL DISORDERS OF LOWER BACK

Musculoskeletal disorders such as impairment of the back and spine; are leading health problems and causes a disability, particularly in people during their employment years. The limitations imposed on the patient are severe, and the economic cost, in terms of loss of productivity, medical expenses, and other costs that are not compensated, is in the billions of dollars.

In the U.S.A the incidence of low back pain is approximately 30-50% of the population acute low back pain (also called lumbago) is the fifth most common reason for physicians visits. About 9 out of 10 adults experience back pain at some point in their life, and 5 out of 10 working adults have back pain every year.

It is estimated that in the United Kingdom up to 4 out of every 5 adults aged 16 or over, will experience back pain at some point in their lifetime whether it be only for one or two days or longer periods of several months. Of these numbers, around one fifth reported it as their first occurrence of experiencing back pain. Around 19 out of 20 reported cases of acute back pain are classed as simple low back pain or as being 'non-specific'. Of these, three-quarters have a significantly reduced amount of pain or pain free and resuming normal activity within 4 weeks; of the remaining sufferers, 9 out of 10 are pain free after 6 weeks. Back pain is more prevalent between the ages of 35 and 55. Estimated costs to the National Health survey (NHS) in 2010 reported that around 481 million pounds per year with a further 197
million pounds in non-NHS costs such as private consultations and prescriptions. Many back injuries occur in the work-place and costs UK business 5 billion pounds annually, with 50 million days of absence and 30% of employers’ accident litigation cases being accounted to back pain. The average number of days lost annually per sufferer is around 19. The actual costs are hard to discover as incapacity and loss of ability to carry out daily activities are incalculable.

Most epidemiological data concerning low back pain (LBP) are related to developed and industrialized countries and there is little information about LBP in the general or working population in developing and low-income countries. This lack of research leaves a profound gap in what is known as LBP in a large part, where the bulk of the world's working population resides. In the present scenario, occurrence of LBP in India is also alarming. Nearly 60% of the population has significant back pain at some time in their life (Sharma et al 2003, Koley et al 2008).

1.4 THE STRUCTURE AND FUNCTION OF A HEALTHY SPINE

The spine (or backbone) runs from the base of the skull to the pelvis. It serves as a pillar to support the body's weight and to protect the spinal cord. There are three natural curves in the spine that give it an "S" shape when viewed from the side. These curves help the spine withstand great amounts of stress by providing a more even distribution of body weight.

The spine is made up of a series of bones that are stacked like blocks on top of each other with cushions called discs in between to help and absorb shock/load.
The spine is divided into three regions:

- **Cervical Spine** — The cervical spine (or neck) is the uppermost part of the spine. There are seven vertebrae within the cervical spine, numbered C₁ to C₇ from top to bottom. The first two vertebrae of the cervical spine are specialized to allow for neck movement. C₁ (also called the atlas like atlas holding the world) sits between the skull and the rest of the spine. C₂ (also called the axis) has a bony projection (odontoid process) that fits within a hole in the atlas to allow rotation of the neck. The first spinal curve is located at the cervical spine. It bends slightly inward, resembling a "C." This inward curve is called a lordotic curve.

- **Thoracic spine** — There are 12 vertebrae (T₁ to T₁₂) in the chest section, called the thoracic spine. The ribs are attached to the spine on the thoracic vertebrae. The curve of the thoracic spine bends outward like a backward "C" and is called a kyphotic curve.

- **Lumbar spine** — The lumbar spine (or lower back) usually consists of five vertebrae numbered L₁ to L₅. (Some people have six lumbar vertebrae.) The lumbar spine, which connects the thoracic spine and the pelvis, bears the bulk of the body's weight and are the largest vertebrae. The curve of the lumbar spine also bends inward (lordotic curve).

Below the lumbar spine is a large bone called the sacrum. The sacrum actually consists of several vertebrae that fuse together during a baby's development in the womb. The sacrum forms the base of the spine and the
back of the pelvis. Below the sacrum is a small bone called the coccyx (or tailbone), which is another specialized bone, created by the fusion of several smaller bones during development. Figure 1.1 shows the Lateral Spinal column and Posterior spinal column and Figure 1.2 shows the Lateral Spinal column with details of vertebrae.

Figure 1.1 Lateral spinal column and Posterior spinal column
1.4.1 Divisions of Spinal Segments

The spine is also discussed by parts: bones (and joints), discs, nerves, and soft tissues (ligaments, tendons, muscles).

1.4.1.1 Vertebrae (bone)

- **Body** — The body is the front portion and the main weight-bearing structure of the vertebra.

- **Spinous process** — The spinous process is the posterior, or rear, portion of the vertebra. It is the bony ridge we can feel down our back.

- **Laminae** — These are two small plates of bone that join in the back of the vertebra.
- **Pedicles** — Pedicles are short, thick bumps that project backward from the upper part of the vertebral body.

- **Transverse processes** — These are the bony projections on either side of the vertebra where the laminae join the pedicles. Muscles and ligaments attach to the spine on the transverse processes.

1.4.1.2 **Facet joints**

These are the spinal joints, the areas on the spine where one vertebra comes into contact with another. Joints allow for movement, since bones themselves are too hard to bend without being damaged. Facet joints are the specialized joints that connect the vertebrae. The facet joints allow the vertebrae to move against each other, providing stability and flexibility. These joints allow us to twist, to bend forward and backward, and from side to side. Each vertebra has two sets of facet joints. One pair faces upward to connect with the vertebra above and the other pair faces downward to join with the vertebra below.

In the center of each vertebra is a large opening, called the spinal canal, through which the spinal cord and nerves pass. The vertebrae are held together by groups of ligaments, fibrous tissues that connect bone to bone.

1.4.1.3 **Intervertebral discs**

Intervertebral discs are flat, round cushioning pads that sit between the vertebrae (inter means "between" or "within") and act as shock absorbers. Each intervertebral disc is made of very strong tissue, with a soft, gel-like center — called the nucleus pulposus — surrounded by a tough outer layer called the annulus. When a disc breaks or herniates (bulges), some of the soft
nucleus pulposus seeps out through a tear in the annulus. This can result in pain when the nucleus pulposus puts pressure on nerves.

1.4.1.4 Nerves

The spinal cord, the column of nerve fibres responsible for sending and receiving messages from the brain, runs through the spinal canal. It is through the spinal cord and its branching nerves that the brain influences the rest of the body, controlling movement and organ function.

As the spinal cord runs through the spinal canal, it branches off into 31 pairs of nerve roots, which then branch out into nerves that travel to the rest of the body. The nerve roots leave the spinal cord through openings called neural foramen, which are found between the vertebrae on both sides of the spine. The nerves of the cervical spine control the upper chest and arms. The nerves of the thoracic spine control the chest and abdomen, and the nerves of the lumbar spine control the legs, bowel, and bladder.

1.4.1.5 Soft tissues

Tendons connect muscles to bone and assist in concentrating the pull of muscle on bones. Ligaments link bones together, adding strength to joints. They also limit movements in certain directions. Muscles provide movements of the body and help maintain position of the body against forces such as gravity. Figure 1.3 shows the various views of vertebrae (Cleveland Clinic 2013).
Figure 1.3 Various views of vertebrae
1.5 LOWER BACK DISORDERS

Various structures in the low back including the intervertebral discs, paraspinal ligaments and muscles are at risk of injury in working environments containing multiple shocks for several reasons including (1) increased mechanical stress caused by seated postures, (2) changes to the way the body responds to multiple loads caused by various postures, (3) pressure changes, tearing, buckling, or softening of the intervertebral disc with exposure to multiple loads, (4) potential changes to the neuromuscular control system which will effect passive and active stabilization, (5) unexpected sudden loading can lead to an overcompensation in the trunk mussels.
response, and (6) buckling events can occur due to an inability of the neuromuscular control system to respond in a quick and coordinated fashion to sudden loading (International Organization for Standardization, 2004

Low back pain (LBP) is defined as back pain lasting for a day or longer in an area between the twelfth ribs and the gluteal folds. Lumbago refers to an acute episode of LBP. Sciatic pain refers to pain symptoms that radiate from the back region down one or both legs.

1.5.1 The Intervertebral Disc Problems

The intervertebral disc problems are degenerated disc, bulging disc, herniated disc, thining disc and disc degeneration with Osteophyte formation. Figure 1.4 shows the various disc problems.
1.5.1.1 Degenerated disc disease

Degenerative disc disease (also called spondylosis) is a general term used to describe changes that can occur along any area of the spine (cervical, thoracic and lumbar) as the age increases, but is most common in the lumbar area. It’s not actually a disease, but rather a condition in which the discs “degenerate,” or lose their flexibility and ability to cushion the spine. The discs don’t have a good blood supply, so once injured it can’t repair by itself. These age-related changes include:

- **Discs dry out and shrink** - made of about 80% water, as the man gets older they slowly lose water. This loss of flexibility puts more stress on the annulus.

- **Small tears occur in the annulus** - sometimes some of the gel-like material, or nucleus pulposus, comes out through a
tear in the wall and touches the nerves. This material has many inflammatory proteins that can inflame the nerves and cause pain. These tears also affect the nerves in the annulus, and small movements, called micro-movements, can cause discogenic pain. Over the years the proteins eventually dry up, and the discs become stiffer; in many people this results in less pain by the time they are in their sixties.

- **Disc space gets smaller** - due to the loss of water in the discs the distance between vertebrae begin to collapse, which is why man get shorter as he age.

- **Bone spurs grow** – without the discs holding apart the vertebrae, they can rub on each other causing abnormal bone growths.

- **Spinal canal narrows** – the stresses of all the above changes causes the ligaments and facet joints to enlarge (hypertrophy) as they try to compensate and spread the load over a larger area. This over-growth causes the spinal canal to narrow, which can compress the spinal cord and nerves causing pain. Figure 1.5 shows the collapsed disc with bone spurs.
Degenerative disc disease causes the discs (purple) to dry out and shrink, reducing the disc space between vertebrae. Bone spurs and tears in the annulus may develop which can lead to spinal stenosis and disc herniations, respectively.

1.5.1.2 Herniated disc

A herniated disc occurs when the gel-like center of the disc ruptures out through a tear in the tough disc wall (annulus) (Figure 1.6). The gel material is irritating to the spinal nerves, causing something like a chemical irritation. The pain is a result of spinal nerve inflammation and swelling caused by the pressure of the herniated disc. Over time, the herniation tends to shrink and we experience partial or complete pain relief. In most cases, if low back and/or leg pain is going to resolve it will do so in about 6 weeks.
Different terms may be used to describe a herniated disc. A bulging disc (protrusion) occurs when the disc annulus remains intact, but forms an out pouching that can press against the nerves.

A true herniated disc (also called a ruptured or slipped disc) occurs when the disc annulus cracks or ruptures, allowing the gel-filled center to squeeze out. Sometimes the herniation is so severe that a free fragment occurs, meaning a piece has broken completely free from the disc and is in the spinal canal. Figure 1.7 shows bulging disc and herniated disc.

Most herniated discs occur in the lumbar section of the spine, where nerves from the spinal cord exit between the lumbar vertebrae, and then join together again to form the sciatic nerve, which runs down the leg. A herniated disc occurs when the gel-filled nucleus material escapes through a tear in the disc annulus and compresses the spinal nerve.

Figure 1.7 Bulging disc and herniated disc

1.5.1.3 Spinal stenosis
Spinal stenosis is a degenerative condition that happens gradually over time and refers to:

- Narrowing of the spinal and nerve root canals
- Enlargement of the facet joints
- Stiffening of the ligaments
- Overgrowth of bone and bone spurs

Stenosis can occur along any area of the spine (cervical, thoracic, lumbar), but is most common in the lumbar area. Nearly every adult's spinal canal narrows with age; however, for most people this does not cause symptoms. Narrowing of the nerve root canal (lateral stenosis) presses on the spinal nerves, causing inflammation and pain. Narrowing of the spinal canal (central stenosis) presses on the spinal cord causing inflammation and weakness.

Lumbar stenosis may cause pain as well as tingling or numbness that starts in the buttocks and radiates down the back of both thighs and sometimes into the calves, called sciatica. Stenosis also causes neurogenic claudication, a cramping pain and weakness in the legs, typically the calves, that occurs with walking or standing and goes away with sitting and rest. Over time the symptoms increase, reducing one’s physical endurance. Leaning over a supporting object, such as a walker or shopping cart, can help reduce the pain when walking.
Figure 1.8 The Normal vertebra and Stenotic vertebra

Figure 1.8 shows the Normal vertebra and Stenotic vertebra. In a normal vertebra, the spinal canal and the nerve root canals have ample space for passage of the spinal cord and nerves. In a stenotic vertebra, bone spurs, enlarged facet joints and a bulging disc constrict the nerve root canals causing compression and entrapment of the spinal nerves; also called lateral or foraminal stenosis. Central stenosis occurs when the central spinal canal is constricted with enlarged ligament and bony overgrowth, causing compression of the spinal cord and cauda equine (Mayfield Clinic 2013).

1.6 NEED FOR THE STUDY

Lower Back Disorder remains the predominant occupational health problem in developing world. Professional drivers are exposed to multiple factors which are considered as risks for lower back disorders (Kittuswamy & Buchholz 2004). Low back pain has unfavourable consequences for vehicle drivers in terms of suffering of pain, decreased quality of life and disability (Solidaki et al 2010, Seidler et al 2011).

It is imperative that information be gathered to assist in designing better working conditions for vehicle drivers, which will enhance their health and well being, productivity morale and efficiency in performing their jobs. Hence, there is a current need to do research focusing on risk factors that might contribute to the knowledge of the development of lower back disorder among the vehicle drivers.

The scientific study (Greek-nomos) of human work (Greek – ergon) is defined to be Ergonomics. Ergonomics considers the physical and mental capabilities and limits of the worker as he or she interacts with tools, equipment, work methods, tasks and the working environment.

Environmental Ergonomics concentrates on the interaction between the user and his or her physical environment. The physical environment includes climate (Temperature, humidity, heat radiation), noise, vibration and lighting, etc. Environmental factors are of paramount importance in determining the employee’s productivity and well being. Hence, Environmental Ergonomics addresses the problem and discuss about the solution for maintaining the human comfort, activity and health in combating stressful environment.
Even though numerous works relating to LBDs have been conducted globally, there are only few studies are conducted in India among the vehicle drivers. Hence an attempt has been made through this work to study and analyse the work related LBDs among vehicle drivers.

1.7 OBJECTIVES OF THE RESEARCH WORK

The main aim of this research work is to analyze the LBD prevalence level among vehicle drivers by constructing a LBD potential environmental ergonomic risk factors model for vehicle drivers. In order to achieve this primary purpose of the research, the following objectives are proposed for the present study.

- To design a LBD prevalence model with the identified constructs, suitable for testing the LBD prevalence among drivers.
- To analyze the LBD causing environmental ergonomic risk factors influencing LBD prevalence among drivers.
- To determine the prevalence of work related symptoms of the lower back disorder in employees who drive the vehicles.
- To test whether the LBD causing environmental ergonomic risk factors individually or jointly influences lower back disorders among vehicle drivers in India.
- To check the relationship between LBD prevalence, Prevention of activities and Medical Intervention.
- To test whether type of occupation (driving the vehicle and office work) exhibit relationship with LBD risk factors, LBD prevalence, Prevention of activities and Medical Intervention.
To test whether individual conditions like age, income, educational qualification, body mass index, exercising habit, smoking, chewing pan/tobacco, drinking alcoholic beverages habit and also type of vehicle and type of suspension provided in the vehicle have relationship with LBD prevalence, prevention of activities and medical intervention among vehicle drivers.

1.8 RESEARCH METHODOLOGY

To begin with an exhaustive literature review relating to LBD prevalence among vehicle drivers was made and potential environmental ergonomic risk factors were identified. The study was conducted among drivers of various vehicles in Tamilnadu. Data was collected from the vehicle drivers using the structured questionnaire. The questionnaire developed in the study is given in Appendices 1, 3.

The study consists of two phases. In the first phase, a preliminary study was conducted and the questionnaire was validated for further use. In the second phase, a final study was conducted. The model developed for the purpose of investigating the LBD prevalence level among vehicle drivers of Tamil Nadu was validated by testing the various hypotheses developed in the study. The validated main survey instrument for testing LBD prevalence level among drivers is given in Appendices 2, 4. Data for both the preliminary study and final study were collected from vehicle drivers by following the stratified random sampling procedure.

Responses were elicited from the vehicle drivers in the five point likert’s scale. Data collected through pilot study was analysed using SPSS version 17.0 for validating the instrument. The results of various validation tests conducted in the study are discussed in detail in Chapter 4. Hypotheses
were developed and tested the model for making proper inferences in the study. For this purpose, all the directional hypotheses were converted into null and alternate hypotheses for testing, correlation analysis, Regression analysis, two sample t-test and one-way ANOVA were used to test the proposed hypotheses. SPSS version 17.0 was used for all the computations.

Results and discussions with regard to final analysis are presented in Chapters 5 and 6. Based on the results and discussions, practical implication of the study and the scope for further research are discussed in the final chapter.

1.9 AN OVERVIEW OF THE THESIS

Chapter 1 of the dissertation discusses about the occupational diseases prevailing in the world and the severity of the work related musculoskeletal disorder especially lower back disorder. It describes the structure, function of spine and lower back disorders. It also presents the need of this research work to overcome the LBD prevalence among drivers.

Chapter 2 reviews the literature presented by several authors with respect to the LBD Prevalence among vehicle drivers. The review resulted in identifying the potential environmental ergonomic risk factors associated with LBD prevalence. The findings of this chapter identify the research gap and research methodology to achieve research objectives.

Chapter 3 describes the conceptual frame work of LBD among vehicle drivers and forms basis for the proposed model by identifying the potential environmental ergonomic risk factors responsible for the prevalence of LBD among vehicle drivers.
Chapter 4 presents the LBD model for drivers. The chapter also includes the results of preliminary survey conducted among 100 drivers using the designed instrument. The results of construct validity, reliability analysis and discriminant analysis are recorded in this chapter.

Chapter 5 underscores the relationship between the individual LBD risk dimensions with the LBD prevalence level and also the effect of LBD prevalence level because of combined effect by all the LBD variables. One or more LBD variables form as a subset and significantly predict the LBD prevalence level and the results are included in this chapter. The relationship between the LBD prevalence level, prevention of activities and Medical Intervention are also tested and presented in this chapter.

Chapter 6 discusses the influence of individual conditions like age, educational qualification, income, body mass index, smoking habit, Pan/Tobacco chewing habit, alcoholic beverages drinking habit, exercising habit, prevalence of lower back disorder in previous job, type of occupation (driving & non-driving), type of vehicle driven by drivers, and type of seat suspension provided on the LBD prevalence, prevention of activities and Medical Intervention due to LBD prevalence among vehicle drivers.

Chapter 7 presents conclusions along with a brief summary of the dissertation. It discusses implications and recommendations for future research. The contributions and the limitations are also discussed in this chapter.