

# Yo Soy Yo Y Mi Circunstancia: My Life as a Cleaner

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## **Abstract**

Initial research by the authors using an online survey of over six hundred participants analysing what (if any) activities lead to discomfort, particularly in the hand, showed that cleaning tasks and in particular, mopping, sweeping and hoovering led to higher levels of hand discomfort than other ADL's (Carre, 2009). Activities of Daily Living (ADL's) such as cleaning, hoovering, mopping, and so on have had little or no previous research undertaken on them. In 2005, Tresea et al., examined the prevalence of work related injury and explored barriers to, and experienced of, reporting them amongst workers. The results showed that over one year, three quarters of the workers studied experienced work-related pain. With reference to the above study, the authors defined two categories of cleaning activity, termed heavy work and light work. 'Heavy' work was characterized by neutral postures, walking, repetitive movements involving the articulations of the upper limb pushing a 1-6 kg (wet or dry) mop, with occasional more intense effort. 'Light' work was characterized by flexed postures, walking, rapid repetitive movements involving the articulations of the upper limb and the movement of light weights (dusting) or 1-3 kg weights (emptying wastebaskets), with more occasional intense effort (Teresa et al., 2005).

It was proposed to study the process of using cleaning equipment such as a mop, brush and hoover and ascertain what factors may lead to discomfort particularly in the hand. However to inform the design of the questionnaire's, tasks to be analysed and experimental set-up, one of the authors took a job as part of this cleaning team and has worked for over two years as a cleaner, logging their own experiences and activities in a diary and recording the experiences of their colleagues.

This paper details those experiences with comments and reflections from the diary work and demonstrates how the experiential approach led to improved design of experiments and data gathering.

## **Keywords**

Comfort, Grip, Daily Living, Cleaning

## Introduction

Whilst cleaning activities were seen to produce the highest pain levels and frequency the authors also wanted to understand the forces in the hand when undertaking these activities. Previous studies carried out on grip force applied to handles but were usually measured on a single axis (Peebles, 2003, Massey-Westropp et al., 2004., Mathiowetz et al, 1985 and Welcome et al., 2004). This approach has been widely used to monitor and control the grip force during glove tests, biodynamic response measurements and many other experiments involving handgrip simulation (Dong et al., 2004, Aliden et al., 2005, Marcotte, et al., 2005). The hand forces in these studies are either grip force or push force.

A few studies have attempted to study the distribution hand force at the hand-handle interface and their dependence on the handle size, grip and push force that could serve as a vital basic for the design handle.

In their 2005 study, Aliden et al., identified the magnitudes and locations of localized pressure peaks occurring at the hand surface as functions of the handle size and static hand grip and push force. In his study, the hand-handle pressure are acquired for three different diameters of circular cross-section handle by using a 16 x 11 pressure sensing grip under different combination of static grip and push force. The result showed that the contact force developed in the vicinity of knuckles and the palm is generally attributed to the push force, while forces at the finger surface are caused by the gripping actions. According to Reidel et al (1995), Rempel et al., (1992), and Radwin et al (1987), the primary factor increasing the risk of cumulative trauma disorders is the operation of some of the tools that demand high grip, push or hand handle contact force. Fransson and Winkel (1991), Pyykko et al., (1976), found that the contact force between the hand and the tool handle can effect the severity of exposure to the hand transmitted vibration and hand wrist cumulative trauma disorder. They also found that the hand arm responses measured in terms of the hand transmitted vibration, and electrical activity of the muscle flexor carpi-ulnaris and finger-flexor muscle, increase simultaneously with the increase of hand-handle coupling intensity, whilst the peripheral circulation of the finger decreases.

Even though, studies have established the magnitude and hand-handle coupling force and various measures of the hand arm responses, the mechanisms leading to the risk of hand-wrist cumulative trauma disorders have not been identified. High contact forces impose high stresses on the anatomical structure of the hand, which may be strongly affected by many factors such as working posture, weight of the tool, grip and push forces, handle size, individual work habits and hand to handle interface pressure (Marcotte P., et al., 2005).

In 2007 it was decided to undertake a PhD project to understand these mechanisms leading to hand-wrist cumulative trauma in more detail. The successful applicant was Mrs S.R. Kamat (Rahayu), and she has over the last two years been studying a full-time PhD at Sheffield Hallam University, undertaking studies into hand discomfort during performing activities of daily living (ADL's). From initial survey work undertaken by the authors on these ADL's cleaning activities such as hoovering, wiping and so on were seen to rate highly on by pain discomfort and pain frequency when compared to other activities. Hence it was decided to understanding the nature of these cleaning activities in more detail. As part of her studies she decided to take a part-time job as a cleaner with a major employer within Sheffield. The initial aim of taking this job was to

understand some of the issues faced by professional cleaners whilst undertaking their normal tasks. Further, the study was undertaken to see how immersive design techniques and the usefulness of those techniques can be used to inform a set of experiments to understand the nature of discomfort and pain during cleaning activities. The diary entries outlined here are purposely in the first person and anecdotal in nature. Typographical errors and language are kept in for authenticity (Rahayu is from Malaysia, and whilst her English is good, it is not her first language and her journal entries were always intended to be informal). The informality of the entries is further emphasized by the use of the term 'Hoovering', which is a British colloquial term for the action of using a vacuum cleaner. Parts of her full diary entries are shown here to how this immersive technique enabled us to design our experiments.

## Diary Entries

Rahayu started work as part of an evening cleaning team working 20 hours a week. The team had 20 members with a mean age of 34, (ages 25 to 40) and was evenly split between genders.

*My experience as cleaner on the first week makes me know how difficult the cleaning activities it is. Most people think the activity is easy, but when I perform the activity frequently every day, I feel more tired and suffer serious pain at my back. The pain increase slightly and continuously up to the present moment. As a part time cleaner in office building, I clean the table, windows and door glass, cleaning bin, washing the cup bin, cleaning the kitchen areas and toilet, mopping floors and hovering around an area (under a table, under chair, edge and lobby) for 4 hour per days and 5 days per week.*

The typical jobs that Rahayu undertakes are shown in the following Figures.



Figure 1: Mopping



Figure 2: Cleaning sinks and toilets



Figure 3: Hoovering



Figure 4: Carry Plastic Bag



Figure 5: Wiping Mirrors, tables and doors

She continues:

*At first, I thought it is the easiest job. I do not experience any discomfort or pain. However, after a couple of month, think change. I begin to suffer a back pain. As time goes by, it becomes annoying. I begin to feel discomfort after one hour hovering and mopping in 30 minutes.*

*Back pain is one of the bigger problems. Every time when I Hoover under the table, the chair, mopping, carrying or washing the cup bin, I have to bend my body. These actions contribute discomfort at my back.*

*After hoovering for about 20 minutes, I felt discomfort at my hand and finger. The vacuum and vacuum handle are so heavy, the air pressure is high and the office areas itself is difficult to Hoover especially hoovering under the table, chair and corner. I have to bend my body and give more grip on the vacuum handle to perform it.*

*The second pain is on the shoulder. When I Hoover or carry bin and cup bin or even washing cup bin, I feel stress at the tender on my shoulder? Sometimes, I take a rest for 10 minutes before continuing Hoover.*

*After 6 months, the back pain becomes more serious. If felt discomfort while doing the hoovering, mopping, carrying and washing cup bin. I take an off for 2 weeks after consulting a doctor. She suggests me to take a rest. All my pains heel after resting in 2 weeks.*

Hence after 6 months of cleaning 20 hours per week Rahayu has had to take time off from her job due to discomfort. After two weeks she returns to work but pains in her back quickly become worse:

*From the back pain, I begin to experience discomfort and pain in shoulder, arm, hand and finger especially after hoovering, mopping the floor, cleaning water bin and cleaning toilet. My hand and finger become stiffness. Some time I feel tender and cramp at the shoulder and arm.*

The McGill pain indicator questionnaire test is used by occupational therapists (amongst others) to describe and rate levels of pain. First developed in 1971, it attempts to gauge the quality of pain experiences. Rahayu refers to it in this next diary entry.

*The discomfort at the hand and finger are increasing from level 2 (mild pain) to level 4 (pain) after frequent cleaning activities. From using one hand, I have to use both hands while hoovering just to reduce the hand grip force, easy to control the vacuum handle and reduce pain at shoulder, arm hand and finger.*

We can see here that her experiences are starting to inform her work. It is also worth noting here that these painful experiences have started to affect the nature in the way she undertakes the task. From using one hand originally she now uses two, completely changing the posture of performing the task.

As part of her studies Rahayu produced a diagram to aid her in understanding the location of the pain in the hand when asking participants about their pain experiences. She refers to these locations in the next excerpt from her diary entry.

This diagram is shown in Figure 6 below:

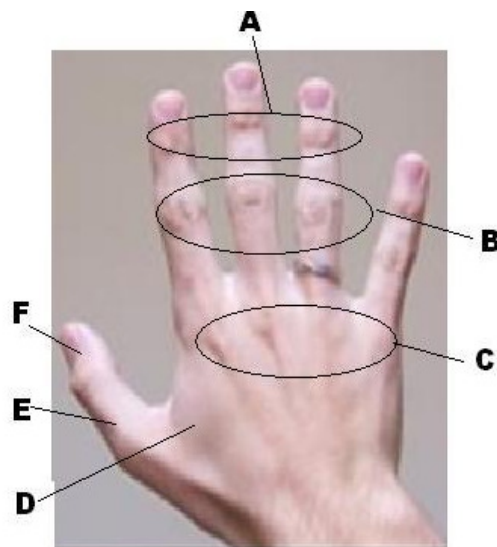


Figure 6: Pain location hand diagram

*After 7 months, I feel the similar pain experience when mopping and hovering. My finger and hand felt discomfort at the area F and E after performing the task. The pains heel after 10 minutes. The similar pain at location A, B and C under the muscle occurs when I carry the water bin and dust bin. The level of pain for both activities is still under level 2.*

*After 8 months, the pain becomes more serious. From back pain, I begin to experience discomfort and pain in shoulder, hand and finger. A lot of hand and finger movement is required during cleaning activity. Therefore, from self experience, I believe that there always discomfort experience by cleaner, especially for those whom work more than 10 years.*

During this period the level of discomfort for Rahayu is seen to continue:

*In month 8th, I begin to feel discomfort in my back pain from the first week till now. My hand and finger feel discomfort after 4 months working till now. The level of pain increase when I clean for a longer period. Sometimes my hand tingle and wrist pain, especially when the task is repetitive strain such as hoovering,*

*mopping a floor and clean table. I felt intermittent pain along the side of the right hand from little finger to wrist when I carry the water bin and waste plastic bag. It is similar the pain location is at A, B and C under the muscle pain, but the level of pain increase to level 3.*

*After 11 months working, the level of pain becomes irritating. My hand and finger become sharp and throbbing at the location C and B. The pain become serious while performing the cleaning activity and the pain cannot heal. Thus I took 2 days medical leave. I put a lotion to reduce the throb. After 2 days rest, I become better. However, I can only work for 2 days.*

Again, Rahayu has had to take time off work to due injuries related to work. However, this time her supervisor decides to change her activities to reduce the impact on her hand.

*A week after, I come back to work as normal. My supervisor gives me a simple task such as clean tables and hoovering without carrying any heavy thing. Although it is simple, I still feel the pain but not serious compared to last week, I still have to put lotion at my hand on location B, C and D to heal the pain.*

*A year past, the level of the pain increased to level 3. The pain felt at location A, B, C, D, E and F but more serious about location A, B and C, the thumb not to be serious pain whenever I carry out my daily cleaning activities.*

*Due to my illnesses, my cleaner supervisor gives me a new task, hoovering the floor. Eventually, it takes about 2 hours to hoover because the floor is too wide. After 2 days hovering, I begin to feel more pain on my hand and finger. Sometimes I have a symptom like numbness in my hand, decrease in griping strength, pain in the finger, pain in the neck and shoulders, tremor in the hand/arms and pain at my back. The level of pain in this task can be categories under level 3 and 4 depend on the certain location. Location A, B and C level 4 and F, E and D under level 3.*

*Base on my experience doing hoovering, I found that some activities look simple but difficult when doing hoovering at certain place for instance under the table, the chair, at the corner and the stairs. My hand and finger move very frequently during hoovering under the chair and table. From my observation when doing hoovering under the table, chair and corner, I found that it has a connection between hand and finger movement with higher grip force, especially when I am bending my body. While doing hoovering under the table and chair I felt more tired and pain at back, hand and finger.*



Figure 7: Hoovering under a table



Figure 8: Hoovering under a chair



Figure 9: Hoovering in the lobby

*I took some photographs of myself hoovering. The photographs show the position of our body while hoovering under the table. We need to bend our body to reach the surface that we want to clean. This movement will be irritating if we have to hoover in a longer period. A lot of hand manipulative movement is required doing the hoovering task especially when hand and finger try to control*



*handle vacuum. As a Cleaner, hovering at the corner and under the table is the most difficult task. The degree in bending our body and hand and finger movement become greater and it needs more force to clean the surface. When I Hoover the carpet I do not have to bend so it is easy.*

Hoovering is generally seen as a difficult task, unless hoovering a bare carpet. Rahayu also talks of other easy tasks:



Figure 10: Wiping a door

*Cleaning the mirror is one of the simple tasks on cleaning activities. I don't feel any pain, when doing this task. We don't need to bend the body on this task but a lot of hand and finger movement is required during doing this task.*

And other 'simple' tasks:



Figure 11: Wiping a computer



Figure 12: Wiping a desk

*Cleaning the table is one of the activities give painful at the back. These activities look easier and simple, but I need to bend my body to reach the surface that I want to clean. A lot of hand and finger movement is required during cleaning the table. This movement will be irritating if I have cleaning many tables in a longer period. The degree in bending our body become greater and it needs more force to clean the surface.*

*A lot of hand and finger movement is required during cleaning kitchen. These tasks are simple but I felt tired when carry the bin and mopping the floor every day.*

From the above diary entries we can see various themes emerging. Posture is seen to massively influence comfort and posture is heavily influenced by the task undertaken, i.e. hoovering under table or wiping a low table surface as to hoovering a carpet or wiping a mirror. Changes in posture during the task also led to changes in grip as the user attempted to control the activity. The repetitive nature of the tasks particularly requiring changes in posture and grip led to fatigue and in some cases significant discomfort leading to illness. The illness itself then in turn started to effect the way in which the task was then undertaken.

Obviously a better understanding of the cleaner activities especially on body posture, hand and finger movement and discomfort and painful feeling when undertaken these activities can aid in the design of products that may reduce instances of discomfort or enable the allocation of work activities so that there is less impact on the body.

Within Lab4living at SHU we have access to motion capture systems and thin-film force sensors to study posture and grip. From the experiences outlined above a series of tests were designed to utilize this equipment with regards producing this improved understanding of posture and grip. Further by embedding herself as part of a cleaning team made access to willing participants for the test work relatively easy.

### **Methods Used (In Situ and Laboratory Studies)**

From the above diary entries several themes emerged that informed the experiments that we wished to undertake. Hoovering was seen as a common task that leads to fatigue and discomfort. Further hoovering posture due to the nature of what the cleaner was actually hoovering (i.e. under a desk, table or chair as opposed to a lobby) was also seen to effect comfort both in the back, shoulder, arm and hand. Changes in posture as

well as manipulation of the vacuum cleaner handle were seen to be contributory factors leading to this discomfort.

As stated previously, whilst there have been several previous studies undertaken to analyze the activities of shoulder and arm muscle during force generation in different shoulder and positions when performing and force using the epidemiological and electromyography (EMG). However little previous studies have been undertaken on the force and hand and finger movement related with discomfort or pain while doing the ADLs activities.

From the diary entries outlined earlier several studies were proposed. Firstly, the authors decided to concentrate on understanding the hoovering task as this was the primary task that lead to most discomfort for Rahayu and tied in with opinions provided by the online survey. Secondly, it was decided to undertake studies both *in situ* and in the laboratory. The *in situ* studies would help us understand which hoovering task created the greatest force in the hand since from Rahayu's dairies some tasks were seen as more difficult than others. The *in situ* studies consisted of using the Tekscan thin-film force sensors on the handle of the vacuum cleaner and measuring the grip forces as the cleaners worked. Over 20 professional cleaners were studied. Figure 13 shows one of the cleaners using the equipment and Figure 14 a close-up of the sensor.



Figure 13: Thin Film Force sensor on vacuum handle *in situ*



Figure 14: Thin Film Force sensor on vacuum handle

Results from the sensor are displayed as pressure 'patterns'. To aid in helping us understand the relationship between these pressure patterns and discomfort the patterns were mapped onto a simple schematic of the hand as shown below.

Color	KPa
Red	>=185
Orange	169
Yellow	154
Light Green	138
Green	123
Light Blue	108
Blue	92
Dark Blue	77
Very Dark Blue	62
Black	46
Black	31
Black	15
Black	>=0

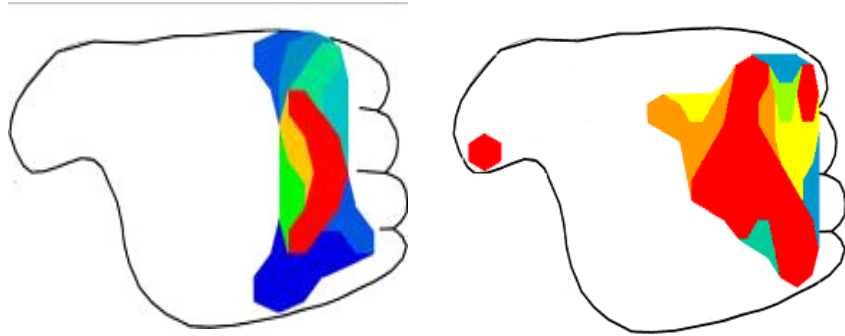


Figure 15: Pressure Distribution on the hand whilst hoovering

The hand on the left is a female cleaner gripping the vacuum handle gently before undertaking the task with the pressure distribution on the right the same cleaners hand during hoovering under a chair. The pressure patterns were seen to be affected by hand size and the task undertaken. Further results are not presented here since this paper is about how the experiential learning informed the experiments. The results from this work are currently under review elsewhere. Following on from this *in situ* work that identified which tasks created the highest 'pressure patterns' the same tasks were repeated in the laboratory combined with motion capture. Motion capture allows for the real-time measurement of movement through tracking of highly fluorescent markers using specialized infra-red cameras. Figure 16 shows the marker set-up including the markers and Tekscan thin-film sensor. Twenty cleaner professional were tested hoovering a carpet, in the corner, under a chair and under table. The cleaners were marked-up with the fluorescent markers to track motion of the vacuum cleaner relative to the task, their hand, arm, shoulders and back position.



Figure 16: Close-up of had set-up for laboratory experiments, laboratory set-up for hoovering under a chair, motion capture analysis

From this technique were able to understand the different actions of the cleaners undertaking these series of tasks and look at the forces in their hands whilst undertaking this task.

## Conclusions

The results from the experiments have only been briefly presented here since the emphasis of this paper is how the experiences of Rahayu working as a cleaner helped in production of a series of experiments. The key insights were:

- hoovering whilst thought of as an easy task, rapidly creates discomfort in the back, shoulder and hand. Hence it was decided to concentrate initially on this task for our experiments.
- differing hoovering tasks create varying levels of discomfort. Interestingly, hoovering in a corner ranks highly for this which we did not expect or originally consider. Also fatigue plays its part, cleaning a bare carpet is relatively easy but becomes uncomfortable if a large area is to be cleaned. Hence a series of tasks were used to replicate the *in situ* environment.
- posture in relation to the task, repetitiveness and hand size all play a part in the increase in force in the hand leading to discomfort. Hence we measured participant height, hand size and repeated each experiment several times before taking a capture.

A major benefit of this experiential approach is the personalization of the issue it becomes a 'real' problem as opposed to someone else's that we are trying to understand. This is important in both enabling us to understand the issues around our research but enables us to discuss these issues with a greater deal of depth, we actually understand the problem. It is not interpreted and filtered in some way. As a researcher one of the most shocking elements to come out of the diary was how quickly Rahayu became ill and had to have to take time off work due to pains in her hand.

A further interesting advantage was the ease of getting volunteers to come to our laboratory and undertake the tasks asked of them. Nobody from Rahayu's cleaning team refused to take part in the survey and further, all the studies were conducted with a great deal of warmth and humour making the studies enjoyable and setting the volunteers at ease. Similarly all participants were happy to come back for further studies on mopping and wiping that are currently being undertaken.

It is worth noting in the preparation of this paper that Rahayu took a photograph of her hands as she was determined to show how her hands had become swollen and scarred from undertaking these cleaning tasks (the scarring comes from a reaction to the latex gloves she used), to that end it is shown below:



Figure 17: Rahayu's Right Hand

Finally, the authors believe that most importantly in 'embedding' herself as a cleaner we discovered how serious this issue actually is. There are as stated previously studies on vibration white finger and heavy (predominantly male) work such as construction, but little in the field of cleaning activities. The authors feel that this paper shows that it is time to change.

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