Using body mapping as part of the risk assessment process - a case study

Thomas, David; Hare, Billy; Cameron, Iain

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Abstract:	This paper reports on a study undertaken to identify levels of MSD in relation to methods of waste collection. The need to quantify and eliminate ill health arising out of work is vital to reduce workplace absence leading to debate on associated relationships between the methods of waste collection and musculoskeletal disorders (MSDs). Body mapping is a participatory research tool that has been successfully used to investigate workplace ill health problems. Participatory body mapping exercises were carried out using staff at a UK District Council 2 years before and after the move from boxes and baskets to a wheeled bin recycling service. The study introduces the concept of Average Pain Count (APC). The data, supports previous studies showing wheeled bin based services (APC 2.07 & 2.80) are associated with less MSD outcomes than services including boxes, baskets and sacks (APC 4.02).The surveys provided compelling evidence to suggest that there are associations between age and self reported pain although there appeared to be no patterns with regards length of service. These findings should help Local Authorities better understand critical factors regarding waste collection strategies and self reported pain. There are recommendations regarding the use of body mapping and for industry practice.
Order of Authors:	David Thomas, PhD, MSc, BSc (Hon) PGCE
	Billy Hare, PhD, BSc (Hon), BA, MCIOB
	Iain Cameron, PhD
Response to Reviewers:	To The Editor Policy and Practice Please see considered response to both reviewers, please pass on the authors thanks in affording us opportunity to improve the quality of the paper. We note the concern from Reviewer #1: who stated that "I do have a number of residual concerns, some quite fundamental that the authors should consider prior to acceptance for publication." In the response we have endeavoured to cover each of the points raised. Most of the points were identified and responded to during Viva by the external examiners and it is pleasing that the second reviewer appears to be comfortable with the methodology. Despite these concerns it must be remembered that this is part of the risk assessment process, is suggested this is a qualitative process because of the nature of 'measuring individual pain' and in effect confirms the validity of the quite extensive literature. The study is epidemiological and by nature requires as greater sample size as possible and repeating elsewhere. What is unique about this study is that a local authority have availed its workforce to a researcher which in itself is a brave process; the work has been done in a collaborative way. The authors hope that you will be satisfied with the robust discussion with the reviewers and the willingness to take on board suggestions to markedly improve the

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Introduction

One of the most frustrating aspects of managing health and safety is being able to identify links between work activity and ill health problems such as musculoskeletal disorders (MSDs) (Bevan et al 2009). This can hinder the development of preventative strategies and early interventions in the workplace. The Waste Management Industry is slow to embrace new technology (Ward 2017) and has limited economic flexibility (Bevan 2015). This paper presents the findings of a study to validate the use of body mapping as a 'non-expert' method of identifying MSD risk.

Mc Gill (1997) suggests that MSDs in the workplace are caused by 4 main mechanisms :

- Static Loading (remaining in one position),
- Shock loading (lifting or handling something very heavy),
- Repetitive loading (the actions around lifting/handling – repeatedly handling light items in a similar manner),
- Lack of rest between activities to allow muscles to recover.

Each of these act together although it is likely that each person will have one significant cause that is personal to them.

Many organisations lack adequate access to occupational health support (Black 2008) with health surveillance often limited to managing physical agents, such as exposure to substances, noise and vibration as required by legislative instruments. Human Resource departments are often reluctant to accept causal links (Hill 1965) between workplace activities and ill health, (Wearing 2018, LCC 2018, and Caldwell-Nichols 2010).This is either the result of a lack of understanding or a belief that they are protecting their employer's interests. As a consequence, irrefutable evidence is required to change their mind-set, invariably meaning statistically significant proof. However, Phillips & Goodman (2004) suggest that "If we can escape from the false dichotomy of proven vs. not proven, facilitated by the non-existent bright line implied by statistical hypothesis testing and by the notion that causality can be definitively inferred from a list of criteria, then we can make decisions based on what we do know rather than what we don't".

The term MSD covers any injury, damage or disorder of the joints or other tissues in the upper/lower limbs or the back (HSE 2013). Froggett (2010) goes on to say that MSDs "are problems affecting the muscles, tendons, ligaments, nerves or other soft tissues and joints. Unlike most other workplace health issues MSDs commonly happen outside the work environment but can be made worse by work, impairing ability to work at normal capacity".

An understanding of the associations between musculoskeletal ill health and work was identified by Roffey et al. (2010), Wai et al. (2010). Kuijer et al. (2007) and Kuijer et al (2000) following investigations between waste collection activities and MSDs. The HSE has also carried out a number of studies in the UK (Pinder & Milnes 2002, and Oxley et al 2006). A summary of the key findings from these studies include:

- Back pain is naturally prevalent in the general population, therefore it cannot be completely prevented through current intervention techniques, although interventions designed to delay and reduce its onset should be considered,
- Waste collection activity is obviously physically demanding, affecting the back and upper limbs of workers,
- There are increased MSD related risks associated specifically with the use of boxed or bagged collection services, safe systems of work are inherently weak on the hierarchy of risk controls and reliant upon supervision,
- The use of wheeled bins for waste and recycling collection is expected to cause less MSD problems than boxed or bagged collection services,
- Severity and complexity of pain is subjective and attempting to measure incremental sub-categories (beyond mere pain frequencies or counts) may be futile-this informed and supported the method chosen, (Fredriksson et al; 2002)
- Good quality appropriate functional capability testing should be available on recruitment and then periodically afterwards,
- The type of receptacle dictates the size, weight and manner of moving each load, which is highly relevant to MSD.

McLeod and Cherrett (2008) identified links between MSDs and the weight of Material handled with. Andersen et al (2003) identifying that high job demand low job control were independently associated with the onset of symptoms of neck and shoulder pain with levels of distress a good future predictor of symptoms. Fredriksson et al (2002) use the word 'relative' when describing risks in this area suggesting a comparative qualitative process consistent with health and safety risk assessments. Indeed when selecting collecting systems there is often no appropriate evaluation of health and safety considerations (Russell and Weston 2011).

Oakman et al. (2016) suggested that MSD risk management and shoulder pain is reactionary and not strategic, but rather through responding to single injuries or incidents. Leclerc et al. (2004), and Cote et al. (2009) have also identified links between throwing loads, e.g. bagged waste, and shoulder injuries.

Costs of workplace absence are often understated with Skinner and Evans (2012) estimating that hidden costs vary up to 20 times the wage or salary costs, Hamilton & McGregor (2011) identify the need to include on-going societal costs, with Pathak (2008) suggesting that the State, or society, bears 70% of the cost due to work related ill health and accidents. Choosing to only review systems of work after a period of worker absence can be the most expensive choice the employer and employee can make, leaving rehabilitation as the only option remaining. Westgaard and Winkel (1996) (Figure 1) suggest that interventions should involve the workers at risk to identify interventions.

Ill Health MSD can be measured in a variety of ways, including recording of self-reported counts of pain (frequencies), obtained via body mapping from the workforce who indicate points of pain over the regions of the body. Dawson et al. (2009), Health and Safety Executive (HSE 2007), & (Society of Radiographers (SoR 2007) all suggest how body mapping can be used as a participatory research tool. Messing et al. (2008) state that the process is "most useful for groups of workers to report pain associated with similar situations".

Body mapping exercises involve asking groups of workers to identify where they collectively feel pain or discomfort, recording the results through use of a chart and/ or a questionnaire, based on the original Nordic Musculoskeletal Questionnaire (Kuorinka et al. 1987). It is undertaken by the group/individuals under investigation at work (in effect excluding those with ill health absence). SoR (2007) states that workers are often reluctant to report aches and pains, thinking they are the only ones suffering and not wanting to be singled out by managers. Body mapping gives employees the opportunity to highlight the problems and contributing to solutions, in effect health and safety consultation (HSE 2008). The use of images to communicate H&S information is an established way of engaging with the workforce (Hare et al 2013).

Body mapping has been used by ergonomists as an intervention tool to investigate a variety of workplace activities from Display Screen Equipment (Thomas 2012) to repetitive tasks (Corlett and Bishop 1976, Keith and Brophy 2004 & Landau et al. 2008).If workers in a particular job pool share health problems then patterns may emerge that are task related (Hazards 1998 & Mason and Williams 2006) suggesting that it can:

- Establish suitability of the individual to work,
- Be an aid to the risk assessment process,
- Prioritise and support ergonomic improvements (also Teiger 1996).

Corlett and Bishop (1976) & Keith and Brophy (2004) suggest that using this technique, together with statistical analysis, it is possible to identify and support associations and establish causal links. Findings can be compared with the literature available and together can be used until hazards are managed to an acceptable level (Mujica 1992).

The aim of the study reported in this paper was to investigate MSDs arising out of different recycling and waste collection systems using bodymapping as a qualitative risk assessment process. This was the first time (to the authors' knowledge) body mapping had been applied as a risk assessment tool for MSDs in waste collection. The objective was to compare different collection methods and work activity with self reported pain, over a four year period to identify any relationships that may exist.

Methods using Qualified Health Professionals also rely on the honesty and participation of the workforce, however such approaches are often individual orientated more costly and potentially slower and difficult to get staff consent. Bodymapping is less evasive, non-expert and quicker and involves all employees within a work group whether they have had absences or not. It allows for intervention by the employer, with the employees consulted throughout the process (Messing et al. 2008) in a noncomplex, pictorial way, *before* pain leads to absence from work.

2 Methodology

A critical aspect of the methodology was how to measure pain. Initial pilot investigations found that trying to determine subsets such as 'acute' and 'chronic', pain caused confusion. Burton et al. (2004) suggests that such classifications do not fully reflect the pattern of pain among the population, suggesting that back pain manifests as an untidy pattern of symptomatic periods interspersed with less troublesome periods.
Due to the lack of agreement over 'categorisation' of pain, all/any counts of pain, experienced by the workforce, and focusing on 'recent' events was measured (Ahmed 2012, Kääriä 2012, Fransen et al. 2001) without any sub classification.

2.1 Use of Body Mapping

Participatory research has been used in a variety of studies since first the documented study by Henry Ford (Birkbeck 2010). Margolis et al. (1986) suggests that body mapping could be used for similar methodological purposes in other studies. If intervening factors can be discounted as statistically negligible then the only significant differences in absence rates would be those related to each system of work.

This technique can be liable to bias as suggested by McQueen and Knussen (2003), Pillastrini (2010) Schierhout and Myers (1996) believe that this approach has "high capacity and can be used with large populations". Margolis et al. (1988) found that high reliability was obtained, despite the use of non-expert judges; secretaries with minimal training. Rivalis (2008) goes on to say that "participatory ergonomic interventions have a positive impact on MSDs, reducing injuries, workers compensation claims and days off".

Yang et al. (2000) claims to be the first study suggesting that work as a household waste collector is associated with self-reported muscular pain. Burdorf et al. (1996) at an animal feed plant found “good agreement” between a self-administered questionnaire and the medical register.

The point at which pain is experienced is variable; consequentially pain relationships are more a reflection of how systems of work can either promote or inhibit inclusive working. (Andersson, 1999). Food waste collection is of particular concern as up to 140l can be pulled or pushed with 1 hand over many distances. Additionally there is bending down on one side and possible twisting as the loader collects, picks up, and empties the food waste bin.

2.2 Methods Used

Three surveys were carried out using the same local authority service (Table 1). The first survey was administered during the original waste collection system in 2010, primarily:

- Weekly collection of refuse in 140l wheeled bins,
- Fortnightly collection of paper, cans and plastic in two 33l baskets,
- Monthly collection of glass in 50l boxes.

The second (2013) and third (2014) was administered after the implementation of the new system, primarily:

- Fortnightly collection of refuse in 140 l wheeled bins,
- Fortnightly collection of glass, paper, cans and plastic in 240l wheeled bins,
- Weekly food waste collection in 20l ‘mini bins’,
- A paid for fortnightly garden waste service using 240l wheeled bins[1].

Messing et al (2008) suggests that there is flexibility on obtaining data (group or individual) and identified that there is no evidence of the benefits of either noting that choice was usually determined by practical rather than scientific investigations.

[1] About 30% of households

The method of data collection chosen was through a group format allowing for workforce engagement (MacLeod and Clarke 2008) and providing opportunity for anecdotal information from the crews to be collated with the support of both local management and Health and Safety representatives (HSE 2008).These participatory methods have been identified by (Keith and Brophy 2004, Messing et al. 2008, Mason and Williams 2006, & Leclerc et al. 2004) as valid methods of data collection. Groups were facilitated to prevent bias and coercion by other group members, as identified by Gill (2008).

Operatives were asked to mark on a chart with an 'x' where they were currently experiencing any type of pain (Figure 2). The only caveat was those who had known sciatica problems where pain was experienced over extended regions of the lower body, to indicate on the side of the sheet that a person had sciatica and not to add numerous 'x's (NHS 2013). HSE (2007) and SoR (2007) both use a blank chart rather than the Nordic Musculoskeletal Questionnaire (Kuorinka et al. 1987). This followed discussion with the Health and Safety Representatives who suggested that this would be less complex for the operatives and reflecting better where pain was experienced at the point of survey.

Data was obtained through working directly with the workforce in a group setting facilitated by one of the authors. The 2010 and 2013 groups were asked to complete the body mapping charts in groups using a communal chart. Although there are no methodological reasons for preferring this technique over an individual approach (Messing 2008), SoR (2007) and Tullet (2011) suggest this would improve worker engagement. However, it was more practical for information to be collected on individual sheets in a group format in 2014 thus maintaining engagement. All surveys were carried out at the end of the shift.

The response rate was higher in 2014 possibly due to increased trust between the researcher and participants, but there was also more operational time made available to meet crews.

2.3 Data Processing

The frequency of 'x' marks in the body mapping form was termed the 'pain count'. The number of marks in each part of the body (Figure 2 & HSE 2007) were totalled and grouped together. These included head (including ear), arm (including elbow), shoulder (including neck and upper back) and knee. Areas of the body were grouped based upon the patterns observed.

Comparison between different work groups allowed different patterns to be determined. Total pain count in each part of the body (and by addition, the whole body) was divided by the number of employees, surveyed. This unit of measurement was termed 'Average Pain Count' (APC) per participant. Whilst the underpinning principles of the technique are accepted as valid and reliable it was still a new method of analysis.

2.4 Intervening Factors

The study accounted for non-work factors identified arising out of the literature review and factors identified during the return to work process recorded by the local authority. A questionnaire (Appendix 1) was collated and used. Results from this were processed via SPSS with appropriate statistical techniques confirming that the work cohorts were not statistically different. e.g. due to sample size, work cohorts (Loaders, Loader/Drivers, Drivers) and the method of collection (Thomas 2015). Training and induction was consistent throughout the period.

2.5 Ethical Issues

Prior to the study Manual Handling Assessments (HSE 2016) and Safe Systems of Work were reviewed and agreement with local management and Health and Safety Representatives was obtained allowing for both monitoring and time with crews to observe actual working practices.

Anonymity of employees was assured, with care taken to minimise the possibility of identifying any particular individual to their employer. Personal information was shredded as confidential waste on completion of the study. Line management were not present during the process with groups. Participants were encouraged to add any other comments relating to their work that they felt was appropriate.

2.6 Assumptions and Observations

The study is based upon local authority collection rounds based upon the whole district with household and bin distribution data available with most crews tending to carry out the same work activity. Crews were also observed to confirm that work activity as described in the Manual Handling Risk assessments (HSE 2013) was accurate.

3 Findings and Results

Body mapping information was processed as identified in Section 2, converting outputs into an Average Pain Count (APC). Table 2 compares the overall APC between work activities. Between 2010 and 2013 the overall the APC dropped from 4.02 to 2.07.[2] Between 2013 and 2014 the APC rose from 2.07 to 2.80. This coincided with increases in both the volume and weight of garden waste that had been operating for 6 months as well as working an extra day. The collection of food waste with slave bin showed an increase in APC between 2013 and 2014 – when there was a combination of longer exposure to the activity as well as additional overtime opportunity collecting garden waste on the 5th day.

Table 3 compares the APC for each part of the body for each of the time periods. This information is shown pictorially on Figures 3– 5, noting that the darker the shading, the higher the APC. When comparing 2010 and 2014 there was a decrease in APC in all parts of the body except the upper leg. This was marginal but could reflect additional walking required post 2012 By 2014 the service had been embedded for 18 months with increased exposure for some staff yet the APC was still around 25% lower in 2010.

Operational differences identified included:

- Staff had longer rest between work activities during 2010 shorter working day.
- Workloads were approximately 25% greater (collecting waste and recycling that was previously collected in 5 days changed to 4 with the 5th day worked as overtime to accommodate garden waste collections).,for approximately 70% of the workforce in

[2] Comparing APC excluding feet, ankles and headaches as these would not be msd type injury

014 than 2013 with the additional garden waste collection, both households and tonnage

- Replacement of 2/3 of the vehicles was undertaken in 2012 with improved seats and suspension systems reflecting the different service needs,

In 2014 the garden waste service had been operational for 6 months affecting 'wear and tear' whereas in 2013 the service had just started. Discussions with operational management confirmed that Drivers tend to be team leaders and do not rotate and share duties.

The process identified that the APC trends match what would be expected in 'laboratory conditions' found in previous research studies (Table 3 compares system APC over surveys and Table 4 compares activities with the highest APC for the three surveys) of different systems. Key findings included:

- The parts of the body with highest APC were the shoulder and neck/upper spinal which decreased from 0.91 to 0.19 with manual handling reduced after the removal of boxes and baskets although this increased to 0.51 once garden waste collections started- anecdotally a Driver stated that some wheeled bins of garden waste exceed the lifting capacity of the machinery.
- Lower back pain remained high for all three surveys (associated with vehicle driving), but also reducing after removal of boxes and baskets, from 0.86 to 0.64.
- Vehicle Drivers had the highest APC in 2010 (shoulder/neck 2.07, lower back, 1.36, and knee areas 0.93), with levels lower by 2014 (shoulder/neck 0.64, lower back, 1.05, and knee areas 0.67). Drivers often suffer with risks due to static posture as they remain seated most of the day – there was also high APC for those who do an equal mix of loading and driving; discussions revealed that those classified as 'Loader/Drivers' did not rotate activity during the day, which may explain higher APCs
- Loaders who handled and sorted materials in 2010 contained in boxes and baskets (arm including elbow, shoulder/neck,) with the activity involving bending lifting and twisting had an APC of 2.08. These operatives also had an APC for lower back pain of 0.76 related to bending down to pick up and throw (side) bagged waste.

- The significant reduction in the throwing of bags also reduced the APC for the arm including the elbow and wrist, reducing from 0.68 in 2010 to 0.5 in 2013 and 0.28 in 2014.
- The next highest APC were Loaders who handled and sorted materials contained in boxes and baskets (arm including elbow, shoulder/neck, and lower back).
- Food waste loaders identified issues with knee pain – observations noted that crew members often pull/push load into a '140l slave bin ' with one hand, have to bend down to lift the food waste bin and have to open the lid of the food bin hence requiring manual dexterity. It was also noted that those who collect food waste in teams of 3 prefer not to share work activity, thereby inhibiting job rotation. Food waste loaders also identified with high shoulder and lower back pain.
- In 2013 the activities with the highest APC were Food Waste Loaders (abdomen-0.67 & lower leg and ankle- 0.67) and Drivers (lower back-0.57, forearm/wrist-0.57 & knee 0.48).
- The activities with the lowest APC were those involving wheeled bin collections excluding food waste and garden waste collections (2.04 in 2013), in effect staff working 4 days a week before the impact of garden waste collection had impacted.
- That Drivers in all studies scored highest in two out of three surveys; this was unexpected as this work activity has always been perceived as lower risk.

In 2014 the APC for Drivers (lower back) was higher (1.05) than 2013 (0.57) but lower than 2010 (1.36). High APC for 'Loader Drivers' (lower back and lower leg/ankle) was also noted in 2014, although this group comprised only 3 employees. The next 5 highest were food waste collectors although affecting different parts of the body than in 2013.

The lowest APC for the shoulder and neck area occurs when there is less stooping and lifting of containers (boxes, bags and food waste caddies) in the waste collection service with the highest APC also including the throwing of bags. At the authority studied the food waste service split between a dedicated crew (2 Loaders and 1 Driver) operating a 2½ T vehicle and larger crews (3 Loaders & 1 Driver) operating a split-podded vehicle that can take food waste plus either waste or co-mingled recycling. In the latter case loaders are able to rotate and change activity. The 2 ½ T food vehicle service comprised a small workforce (8 Loaders) using 12 month old vehicles and cannot rotate activity.

The results suggest that back pain in itself is not the only significant type of MSD injury with pain in shoulders and the neck. Most HR employee recording systems (Caldwell-Nichols, 2010,) ignore the part of the body affected, this makes the investigations and associations of specific MSD injury far more difficult.

4 Discussion

McGill (1997) suggests that MSDs in the workplace are caused through 4 main mechanisms that act together.

This study adds to the work Kuijer et al. (2007)and Kuijer et al (2010) in helping to identify the causes of MSD's and suggesting interventions in the form of preferred collection methods and practices. This study supports the findings of the "Work Foundation" (Bevan et al. 2009) indicating that work is often contributory to MSD's with many employers not making adequate improvements to workplace practices.

The method has correctly identified the same issues identified through other (more time consuming and costly) methods and is therefore a 'valid' method of (Keith & Brophy 2004) identifying links between the outputs from workgroups surveyed with predictions from the literature (Mujica 1992). It is expected that there should be a higher APC with the collection and sorting of material in boxes and baskets. If the body mapping method is valid then this is exactly what should be expected, per Pinder & Milnes (2002), and Oxley et al (2006). The system of work with the highest APC was the system with boxes and baskets, 4.86 (2010), far more than without, 2.04 (2013) and 2.76 (2014), with the highest neck/shoulder pain at 1.12. The other findings also reflect increases and decreases in APC where work activities were expected to influence MSD (Andersen et al. 2003 Cote et al. 2009).

The findings confirm links between awkward occupational postures and low back pain, in effect bending and twisting and lifting boxes and sorting recycling into different components and bins (Roffey et al. 2010 and Wai et al. 2010). Also activities where there are effects of throwing sacks (Leclerc et al. 2004 and Cote et al. 2009) cause differing /raised APC .

The 2014 outputs show that there is less pain experienced when there are aspects of job rotation (Kuijer et al. 2010) because of the variation of task, reducing the effects of static loading, therefore reducing MSD risk. Reduced levels of APC for drivers in 2013 and 2014 coincided with the introduction of a fleet of new vehicles with better suspension and less vibration. Drivers suffer static loading (McGill 1997) due to remaining in the vehicle for operational and safety reasons. The APC for loaders was lowest in 2013, however this increased in 2014, which coincided with 240l wheeled bins full of co-mingled recycling including the weight of glass being used, as well as increased garden waste collection, supporting McLeod and Cherrett (2008).

During the study it was identified that 240l wheeled bins full of garden waste are far heavier to pull than those containing comingled recycling and residual waste – and collecting on an additional day - in effect increasing the factors identified by McGill (1997) then if the method was valid it would show an increase in APC. Between 2013 and 2014 the APC increased for this work group from 2.04 to 2.76 demonstrating agreement with McGill (1997).

The findings indicate a higher prevalence of shoulder and neck pain when throwing bags and handling of boxes and baskets; APC decreases when the designed system comprises less bags and boxes. Bags and boxes cause more shoulder and neck pain than wheeled bins as identified, Leclerc et al. (2004), Fredriksson et al (2002) and Andersen et al. (2003) and neck pain (Cote et al. 2009).

Westgaard and Winkel (1997) suggest that there will always be non-work elements of ill health, due to lifestyle and ageing through natural deterioration. Each of these work together resulting in challenges for employers in finding suitable work for people who do have MSDs; in effect requiring ‘rehabilitation’. Physical work, even if following correct manual handling techniques, does accelerate natural wear and tear and, if not managed can result in physical work becoming a barrier to productive work. A paradigm shift is required in how employers view ill health, supported by good quality data to move to seeking prevention and improving employability (Kuijer et al 2007). This shift has to include valuing how we include relative risk processes (Fredriksson et al 2002) to improve traditional risk assessment processes.

The study confirms the HSE (2016) by indicating that the onset of pain for loaders are affected by the weight of the load (type of material and collection frequency), the distance the load is carried/moved (where the collection point is) , the design of container (bending down for food waste containers) whether lifted or pushes/pulled and the height of lift point.

One of the practical problems arising out of body mapping exercises where there is staggered work completion time is to ensure there is clear and organised management of the engagement process. It is important that there is a second person available to log any (qualitative) comments from the workforce to support the facilitator and take questions. What was missing was adequate opportunity to record all the points identified and to note any outputs from the interaction between participants and facilitator, thus completing the engagement process.

There are operational challenges relating to changes to working patterns in 2012, drivers were in effect driving for 25% longer. Without positive moves to train more drivers /job rotate it is expected that drivers will still experience pain due to increased static loading. Loaders are walking further, pulling slave bins for a longer period of time when handling food waste and pushing/pulling heavier wheeled bins having moved to fortnightly collections with less rest.

5 Conclusions

The study has identified relationships between pain quantity and distribution, experienced by the workforce undertaking different collection systems as represented by (b) in Figure 1 (Westgaard & Winkel 1997).

APC increased and decreased where expected, driving without breaks showed an increase, lifting, carrying and emptying smaller containers showed an increase, pushing and pulling wheeled bins showed a decrease, (having a rest day showed a decrease), in line with other studies that have used more sophisticated methods. Therefore Body Mapping has been shown to be a valid, inexpensive, non-expert alternative that gives accurate enough 'proxy' measures to manage MSD.

The high APC for food waste collection in 2014 is a cause for concern as this is something rolled out nationwide by authorities between 2013 and 2018. The physical nature of loading (with regards tonnages lifted and distances walked) is such that pain levels created are above individuals' pain threshold hence translating into higher absence rates.

This study:

- Identified areas of the body where self-reported pain was highest (in terms of APC),
- Identified the presence of pain giving opportunity for management intervention,
- Highlighted high risk activities both within and between services to be compared,
- Supported the Councils strategic decision to move away from boxes and baskets to wheeled bins, resulting in less self-reported pain,
- Identified that the additional weight of a container may also increase the risk of MSDs a consideration needed when deciding collection intervals
- To reduce effects of static loading introduce more flexible working practices,

The main implications for theory and practice are:

- That body mapping is a tool that has a variety of uses, including risk assessment, and can be used in a waste industry setting and help to confirm the success of MSD ill health interventions,
- That APC can be used as a measurement tool to compare the prevalence of pain between different distinct cohorts and a tool to facilitate longitudinal studies,

- That it engages with the workforce and encourages them to take an active part in determining their own health and safety solutions.
- That too little enquiry has been devoted to vehicle driver discomfort due to prolonged sitting.

By adapting Body Mapping as a risk assessment tool it is possible to compare different work activity by looking at an Average Pain Count (APC) allowing for improved comparisons to be made. With the removal of the retirement age in the UK and an ageing workforce the working population is increasingly likely to have a MSD history.

6 Recommendations

There are a number of recommendations both for the development of the method and industry policy and practices regarding waste collection.

6.1 Development of the method

- The ‘principle’ of body mapping as a valid method has been demonstrated, but a wider study is recommended to enable a broader analysis to be carried out
- Further studies are carried out comparing ill health absence data and to include further statistical analysis
- Comparison is needed between ill health absence and APC
- Further studies are required to compare the effects of age and length of service

6.2 Policy and Practice Regarding Waste Collection

- Avoid or reduce the use of boxes, baskets and bagged waste to help prevent and minimise MSD pain and subsequent illness,
- Seek alternative methods for collecting heavy garden waste and food waste systems that reduce use of a slave bin.

- Seek to design rounds with short intervals between collection.
- Review and further explore issues around the comfort and health of vehicle drivers.

Previous studies have established that using boxes and smaller containers is detrimental because this increases the pain experienced by operatives. The study reported here has confirmed this using body mapping before and after the reduction of smaller collections in a real-world setting, therefore Local Authorities should discontinue ‘box type’ collections on MSD grounds as a matter of urgency.

The use of body mapping helps to visualise MSD risks, which in the longer term could influence the paradigm shift that is needed as suggested by, Bevan (2015), with focus on making work more accessible, promoting prevention and to improve employee physical wellbeing.

The method also overcomes the barriers around staff being reluctant to report aches and pains as identified by SoR (2007)

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Appendix 1

Nine questions requiring a yes/no response (and allowing for any comments) were asked and allowed for comparisons to be made. Comparisons were made and tested to see if this could skew any comparisons between groups using the Pearson chi- squared test as follows:

(i) Different sample size to identify the extent of any non-work/intervening factors

(ii) Job (Loader/Driver/Loader-Driver), to identify the extent of any non-work/intervening factors

(iii) Collection Technique (boxes, wheeled bins) to identify the extent of any non-work/intervening factors.

This information included lifestyle questions based upon the earlier information gathering process in Section 4.7, extending into pre-employment histories. SPSS was used to calculate the mean and 95% confidence intervals (IBM 2010).

1 More serious health issues

The first questions were designed to obtain a better insight into the severity of any medical conditions that employees may have. These questions were:

- Have you ever had an operation on your back/upper limbs?
- Have you ever had to have physiotherapy for a back/upper limbs problem?
- Have you ever had to visit your doctor for a back/upper limb related problem?

2 Lifestyle factors

Through a more detailed study of several authorities, absence records and return to work process it was possible to obtain an indication of several non-work factors:

- Do or have you played a sport such as football or rugby?
- Have you had a sporting injury?
- Do or have you done building or ground work?
- Do or have you ridden a motor bike or scooter?
- Do or have you been involved in a road traffic accident and suffered an injury?
- Do or have you had to care/support someone with mobility restrictions or confined to bed?

The final question was an open question (if you have had a back/upper limb related problem not covered by the causes above please indicate them in the box opposite) and did not elude to any additional data covered in the other questions.

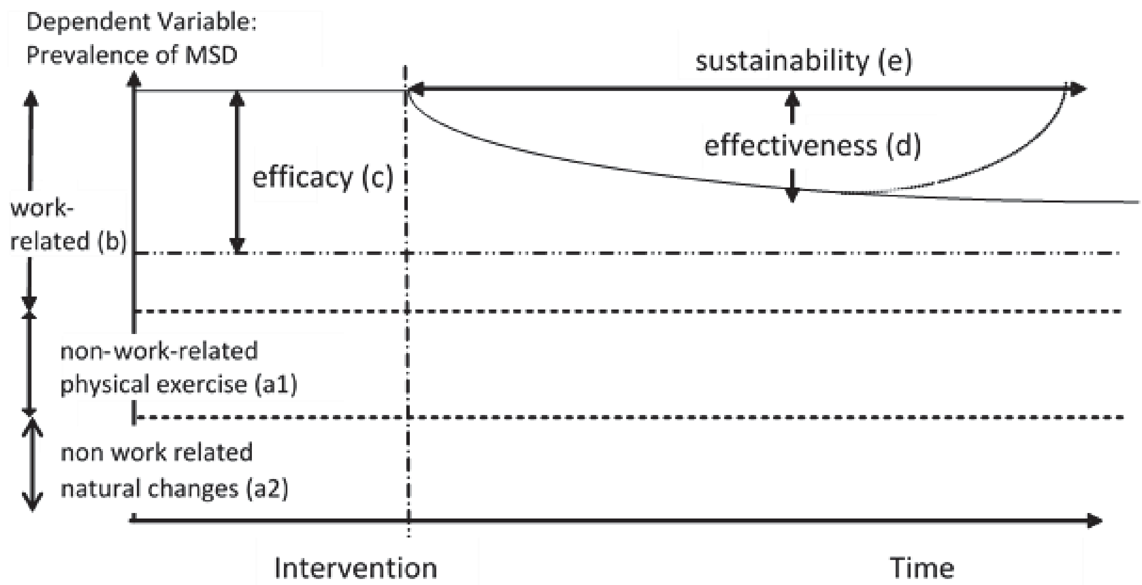

Figure.1 **Graphic presentation of some important terms in ergonomic intervention research reflecting human physical changes.1 (After Westgaard and Winkel 1997)**

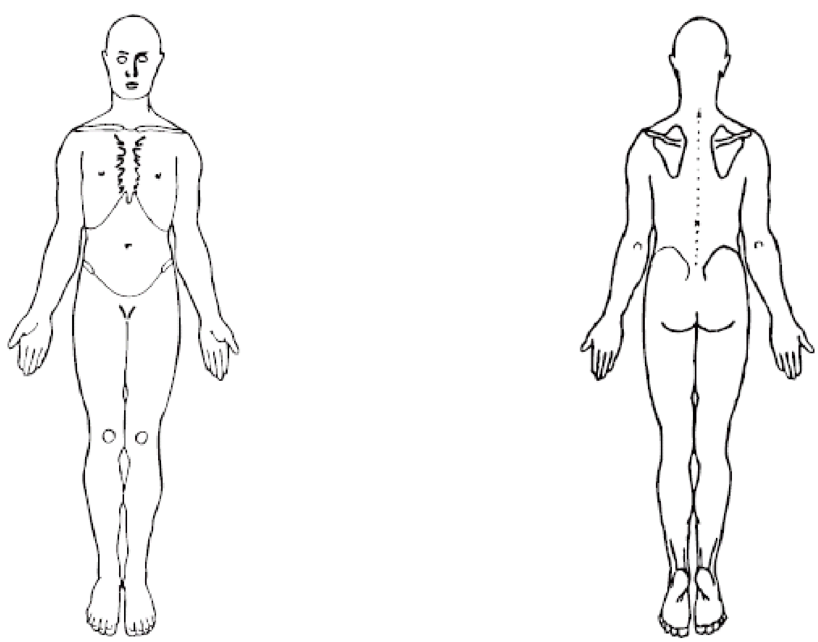

Figure .2 **Specimen Body Map Charts (after SOR 2007).**

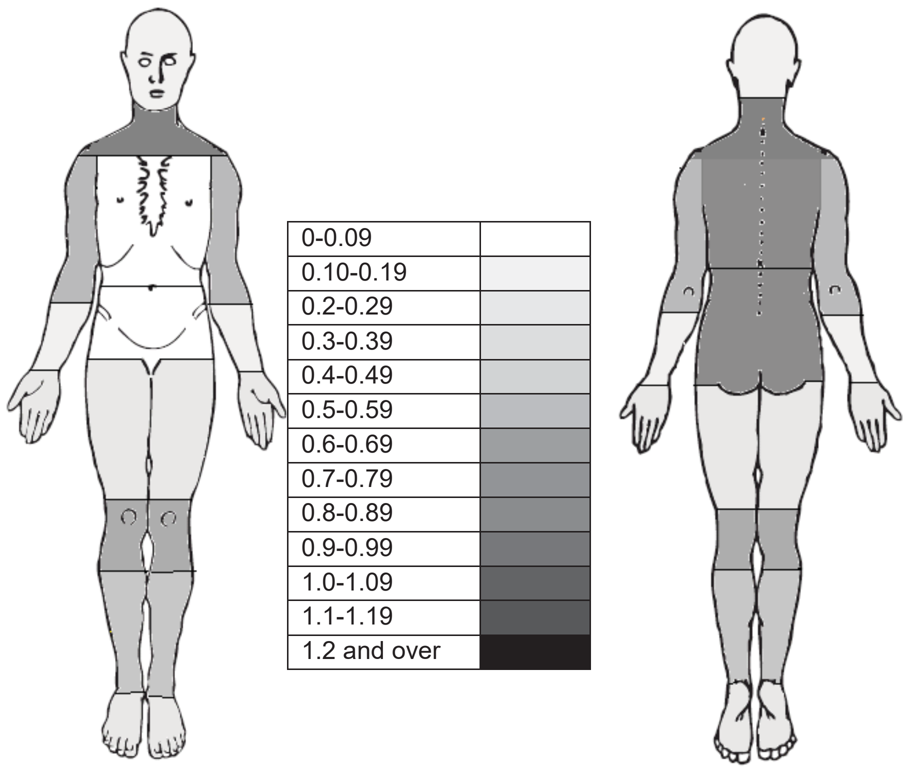

Figure 3 APC 2010

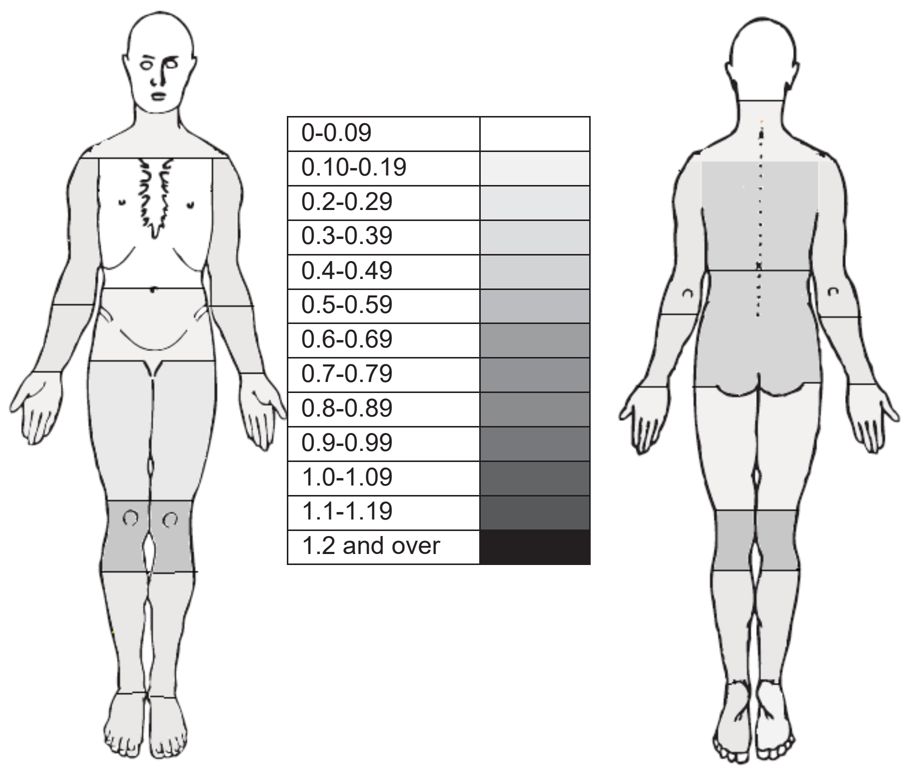

Figure 4 APC 2013

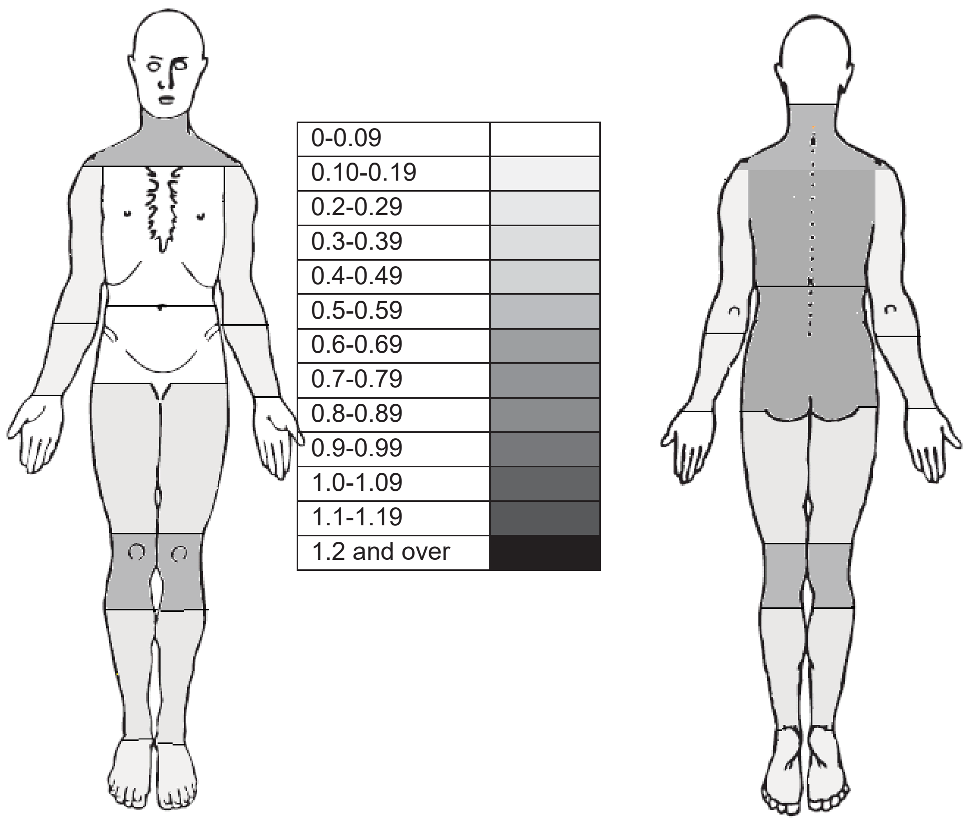

Figure 5 APC 2014

Tables

Table 1 Summary of body mapping data gathering process.

Survey	Date(s)	No of Staff Surveyed	When in the day	Food & Garden Waste collect
1	30/11/10 to 02/12/10	70	End of shift	No
2	21/02/13	54	End of shift	Yes
3	24/09/14 to 22/10/14	89	End of Shift	Yes

Table 2 – Comparison of APC due to Activity (excluding foot, and head)

2010		**2013**		**2014**	
				Activity	APC
Loaders-Baskets & Boxes Recycling	4.68			Loader, Mixture of all activity	2.37
		Loader - Food waste with slave bin mainly	1.84	Loaders – food waste with slave bins mainly	3.36
Loader Wheeled Bins Refuse + Sidewaste	3.00	Loader Wheeled Bins	2.04	Loaders –wheeled bins	2.76
				Loaders/Driver – all activity	2.33
Drivers – all activity	5.14	Drivers – all activity	2.18	Drivers – all activity	2.95
Average for whole service	**4.02**	**Average for whole service**	**2.07**	**Average for whole service**	**2.80**

Table 3 Comparison of APC (all pain).

Part of the body	**APC 2010**	**APC 2013**	**APC 2014**
Head – including ear	0.17	0.00	0.01
Arm including elbow	0.54	0.24	0.17
Shoulder including neck	0.91	0.19	0.51
Forearm including wrist	0.14	0.26	0.12
Back (mainly lower)	0.86	0.33	0.64
Hand and Fingers	0.20	0.13	0.06
Chest	0.03	0.00	0.01
Abdominal	0.07	0.17	0.03
Upper Leg	0.17	0.11	0.25
Knee	0.61	0.43	0.56
Lower Leg and Ankle	0.49	0.22	0.45
Foot and Toes	0.26	0.24	0.19
Total	4.46	2.31	3.00
Total less foot, toes and head[1]	**4.02**	**2.07**	**2.80**
Percentage Response Rate [2]	**96**	**71**	**95**
Average Age (years) by those declaring	**38.42**	**38.25**	**38.63**
Average length of Service by those declaring	**6.20**	**5.88**	**8.03**
No of staff surveyed	**70**	**54**	**89**

[1] Pain in these areas not associated with MSD injuries

[2] The percentage response rate is the total number of completed forms divided by the staff required to operate the service on a daily basis which was considered the most consistent metric

Table 4 **APC, Highest by activity - - Roles are self identifying and indicate employees predominant activity**

2010			**2013**			**2014**		
Activity	Part of the body	APC	Activity	Part of the body	APC	Activity	Part of the body	APC
Drivers	Shoulder including neck	2.07	Loader –Food Waste(Slave Bin)	Abdomen	0.67	Driving All Activity	Back (mainly lower)	1.05
Drivers	Back (mainly lower)	1.36	Loader –Food Waste(Slave Bin)	Lower Leg and Ankle	0.67	Mixed Activity - Loader Driver	Back (mainly lower)	0.78
Loader Boxes and Baskets	Shoulder including neck	1.12	Driving All Activity	Forearm and Wrist	0.57	Mixed Activity - Loader Driver	Lower Leg and Ankle	0.78
Loader Boxes and Baskets	Arm including elbow	0.96	Driving All Activity	Back (mainly lower)	0.57	Loader –Food Waste(Slave Bin)	Knee	0.73
Drivers	Knee	0.93	Loader -Wheeled Bins	Knee	0.48	Mixed Activity - Loader Driver	Knee	0.67
Loader Boxes and Baskets	Back (mainly lower)	0.76	Driving All Activity	Knee	0.48	Loader –Food Waste(Slave Bin)	Shoulder including neck	0.64
Loader Wheeled Bin/Bags	Back (mainly lower)	0.71	Loader-Wheeled Bins	Shoulder and Neck	0.40	Loader –Food Waste(Slave Bin)	Back (mainly lower)	0.64
Loader Wheeled Bins/Bags	Lower Leg/Ankle	0.55	Loader –Food Waste(Slave Bin)	Hand/Fingers	0.33	Loader –Food Waste(Slave Bin)	Lower Leg and Ankle	0.64