Highlights

The design of waste collection activity is related to Musculoskeletal (MSD) ill health.

Body-Mapping is a useful tool for predicting MSD ill health absence.

The HSE Risk Comparator Tool (RCT) can be used to evaluate service health risk.

The RCT requires a full review.

Services using wheeled bins have lower MSD absence rates.

1.   Introduction

Background

In the UK, geographically based Local Authorities (LAs) or Councils provide a multitude of services such as social care, schools, housing, planning , environmental health, waste disposal ,and domestic waste collection (LGA 2020). LAs are independent governance structures and can either operate services with their own staff or outsource to a small number of private sector contractors who may work for a number of LAs**.** Of the services undertaken by LAs, Domestic Waste Collection is the activity with the highest health and safety risks (ESA 2018). The waste sector is characterised by low competency levels (EU Skills 2010) and significant health issues (Naylor 2014).

One of the greatest challenges faced is to increase recycling rates (UKG 2019 and EU 2008) which had plateaued at 45% in 2019 (DEFRA 2019). This, combined with lower operating budgets, (Frew & Breheny 2020) can affect systems of work, which must not increase worker ill health absence (Thomas et al 2019 and Widanarko et al 2012). Of equal difficulty has been how to integrate Health and Safety considerations into the decision making process (WYG 2011 and HSE 2010a) as well as the importance of developing a sustainable workforce (Black & Frost 2011, UKG 2010, Gladwin et al 1995, and Herrera & Heras-Rosas 2020). Kobayashi et al. (2018 p808) suggested human sustainability is "the fulfilment of human needs on the path toward corporate sustainability".

Working collaboratively, the issues highlighted above were investigated through five LAs in the UK, who each had a different system of work and were in the process of reviewing their collection systems. This study adds knowledge to the research gaps identified by Joshi & Deshpande (2019) when comparing ergonomic assessments, and by Emmatty & Panicker (2019) in providing ergonomic interventions (Yassierli 2017), regarding musculoskeletal disorders (MSD).

Existing tools for measuring such ergonomic risks include the Health and Safety Executive (HSE) Risk Comparator Tool (RCT) (HSE 2010b, Turner et al. 2008) that allows for all service risks to be compared for a given geographic or LA area with different collection systems and/or receptacles.

The aim of this study was to compare the manual handing element of the HSE tool through comparison with ill health absence data and self-reported pain through body mapping (Mujica 1992) using data from LAs. Such an aim needs to consider the type of receptacle, which dictates the size, weight and manner of moving each load of waste, all of which contributes to MSDs (Widanarko et al 2011). The objective of the methods used is to measure criteria indicating MSD risk to employees collecting waste. Therefore, there should be a correlation between MSDs/Body-Mapping Data and the RCT if the fieldwork data matches the theory (the tool), then any limitations in the data collection can be considered negligible.

The ease of use and validity of an MSD risk comparator tool for LAs needed evaluation in relation to the collection systems available. Conversations with operational contacts at over 50 UK LAs confirmed that the RCT was not routinely used as an aid to the decision making process. No evidence was presented in literature surrounding this 'tool' to indicate that it has been subject to academic scrutiny or further comparison in all or in part.

Management of MSD Risks
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) including muscles, tendons, ligaments, soft tissues and joints. Unlike most other workplace health issues; MSDs are also created outside the work environment (Westgard & Winkel 1997) but can then be made worse by work. They can impair ability to work at normal capacity" (Froggett 2010). As McGill (1997) notes, each work activity has different elements of different routes to MSDs.

MSD risk is influenced by a number of factors, including the weight of the load, movement such as twisting and bending, the amount of repetition and distance carried (HSE 2013). Movement to alternate-week and three-week collections of municipal waste (Read & Mayne 2017) has increased the weights of receptacles collected (McLeod & Cherrett 2008). In some cases, this has been the result of LAs identifying non-safety (economic) benefits for reducing the frequency of kerbside sorting (Potter 2012).

In the UK, there is a requirement to carry out a suitable and sufficient risk assessment both on commencement of a new work activity but also after changes made to the working environment

(HSE 2009). The theoretical risks around waste collection are well established with Borg et al. (2000) finding that work environment factors such as repetitive work and ergonomic exposure predict a worsening of self-rated health over time. Despite this, the adequacy of the risk assessments have been criticised when authorities introduce segregated glass collection in boxes to remove glass from co-mingled systems (Gray 2013, Read 2013, Anastasi 2013, Warburton 2019, Hughes 2018) with others moving from kerbside sorting to co-mingled collection (Slow 2019) using wheeled bins.

Fredriksson et al (2002) and Landau (2008), identified relationships between work environment and neck and shoulder pain. Williams and Cole (2013) ascertained that a single stream recycling service gives an increase in the weight of material collected when compared with a two stream (including boxes) service. Schibye et al (2001 p558) identified that the "torques at the low back and the shoulders are lower during pushing and pulling compared to lifting of the same amount of waste", influenced by vigorous movements present throughout the lifting process.
The HSE encourages employers to look at ill health absence data to monitor work related MSD risks (HSE 2020). However, such data is difficult to obtain with very few studies in this area (Thomas 2019) and reviews of the success of interventions to reduce sickness absence being inconclusive (Odeen et al 2013). Challenges include data protection laws, meaning difficulty in sharing both within and between organisations together with Human Resource (HR) Management collecting it for purely absence management interventions (Lincolnshire Council 2020).

There are other sources of data available to manage MSD risks, including 'body-mapping', (Figure 1) a participatory method that can detect diagnosed MSDs but also identify early signs of impending damage (Messing et al. 2008). The process involves participants marking where they feel pain on an outline of the human body or manikin (Keith & Brophy 2004). It can be used as a risk assessment tool (Thomas et al 2018) and can be carried out by Health and Safety professionals or representatives in the workplace

Although the process is considered subjective, relying solely on the honesty and participation of the workforce (Corlett & Bishop 1976), it can be potentially more informative than relying purely on absence rates. It involves all employees within a work group whether they have had absences

or not. It can be used as a precursor to absence and hence allows for intervention by the employer, with the employees consulted throughout the process (Messing et al. 2008).

Waste Collection System Design

In England and Wales, LAs are required to collect glass, paper and plastic by separate collection (UKG 2012). Recycling and waste can be collected and sorted in various ways (and includes sorting into constituent parts (e.g. paper, plastics, metals etc.) at the kerbside, taken to centralised premises, such as transfer stations or Materials Reclamation/Recycling Facility (MRFs), for sorting and or processing, or a mix of these two methods (HSE 2011). Choices for waste collection methods have gravitated towards lowest cost for maximum recycling (Williams & Cole 2013), together with strategies to reduce greenhouse gases and general carbon dioxide emissions (Conrad 2010).

Each system has its own specific combination of manual handling risks (Table 1) such as food waste collections creating more ill health concerns arising from weekly collection of food from a 20-litre container (Pinder & Okunribido 2019). The container is generally collected at the operatives' knee height with contents transferred into a wheeled bin pulled by the operative from door to door and emptied into a collection vehicle when full – in some cases compressed to maximise capacity. This variation of postures (Dianat et. al 2020) suggests that there could be additional lower back problems due to repeated bending and lifting of the container, and shoulder problems due to continually pulling a load, both requiring a posture change for a positive intervention.

There have been innovative bin-designs with split containers allowing for source segregation (Thomas 2011), with many UK authorities also moving to a separate food waste collection service as a result of UK waste strategies (Mills & Andrews 2009). The Waste and Resources Action Programme (WRAP) (Quested & Johnson 2009) estimate that the amount of food (including liquid and solid foods but excluding drink) wasted per year is, by weight, 25% of that purchased, all collected at ankle height.

Work activity involving varied receptacles that can cause MSDs has similarities with other industries with repetition, forceful exertion (throwing), bending, awkward posture, manual

materials handling, (Zare 2020) and often insufficient recovery time (Otto & Scholl 2011). Due to the conflict of strategic directions, service providers are limited with regards to ergonomic interventions (Emmatty & Panicker 2019) with Zare et al (2020) stating that it is vital to involve stakeholders when redesigning the workplace to reduce risk factors.

2   Materials and Methods

The methodological approach was to use triangulation (Jick 1979) to compare different information sources and test for consistency of results. Figure 2 summarises the relationship between the three methods used: the HSEs risk comparator tool, average MSD absence rates and self-reported pain from those at work with Figure 3 summarising the methods used. The method used is designed to negates any differences between management approaches.

In 2018, the UK had 390 LAs responsible for domestic waste collection with approximately 210 outsourced to waste management companies. Approaches were made to the major UK waste contractors who declined to participate. This led to a convenience sampling approach (Lund Research Ltd, 2012, Garrido et al., 2015, Etikan et al., 2016 & Thomas et al., 2019). All LAs identified as having in-house waste collection services were contacted via their networking groups. Of this, 63 were further contacted following the initial invitation to participate, with 15 prepared to share ill health data. Of this group, five LAs were prepared to allow access to their workforce to carry out the survey for MSD (Thomas et al 2019). One LA, which had changed its system of work during the study, gave permission to survey its workforce twice, before and after implementation of a new collection system (Thomas et al 2018). This meant that six different systems of work could be compared.

This approach is consistent with studies commissioned by the HSE in the UK (Naylor 2014 & Henry 2010) . This method also allowed for comparison within each authority of their collection assessment activities and minimised confounding factors such as age and length of service. All LAs received visits from HSE Field Inspectors during the research period with no resulting enforcement action.

Measurement of Self-Reported Pain

For the measurement of self-reported MDSs, the 'body-mapping' technique (Thomas et al 2018) was chosen. The method of data collection was through a group format allowing for workforce engagement (MacLeod & Clarke 2008) and providing opportunity for rich qualitative information from the crews to be collated with the support of both local management and Health and Safety representatives (Coulson & Christofides 2020). Groups were facilitated by the authors to prevent bias and coercion by other group members, as identified by Gill et al (2008).

Groups of workers were asked to identify the amount of self-reported pain towards the end of the working shift. Operatives were asked to mark on a chart with an 'x' where they were currently experiencing any type of pain (Figure 1). 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 (Euro et al 2019).

The number of participants was recorded including those who reported no pain. Table 2 compares the demographics of each of the LAs who took part. Employees were not compelled to take part with some older workers in one LA reluctant to declare their age. The total amount of pain marks was totalled up for each sheet. This enabled an Average Pain Count (APC) per employee to be calculated for all MSD injury to be obtained by dividing the total amount of marks (excluding head, ankle and feet) by the number of employees surveyed including 'nil' responses. This cohort of workers therefore incorporates those suffering pain from MSD but able to work. This study combined data from each sheet into one sheet to enable different authority systems to be combined consistent with the RCT. Individual authority data was shared with the authorities to allow for local interventions after completion of the study.

Comparison of ill health absence statistics

Initial data from LAs identified inconsistency with regards to ill health categorisation and recording (Ritchie et al 2009). To overcome this, we based our data collection technique on Holmes (2009) and Henry (2010) that recorded each period of absence including the nature of absence, date of birth of the employee and the first date of absence.

Ill health data was obtained from local authorities using the same data collection technique as Thomas et al (2019). All absence for relevant categories was collated, with descriptors including MSD, Back Pain, Neck Pain and Shoulder Pain enabling us to identify ill health associated with lifting and carrying. It was not possible to break down absence into individual work activity, such as loading or driving, but it was collated as one group enabling analysis as an organisational system or work consistent with the RCT.

Each organisation provided details of the number of staff required to operate daily for each activity to provide a constant method of comparison purposes. This data was collated using a Microsoft Excel workbook for each work activity enabling the total number of days lost to be obtained. By dividing the number of annual days lost by the number of staff required to work on a daily basis, it was possible to compare absence rates between authorities using a common process and eliminating organisational differences. We also compared one authority who changed its system during the study period by obtaining data both 12 months before and after the change.

HSE's Risk Comparator Tool (RCT) – Manual handling element

The risk comparator tool (Turner et al. 2008) was designed and piloted (Table 3) to evaluate the different waste systems used by LAs and contractors in order to compare 'risk-levels' against different methods of waste collection used. It creates a risk rating, using and weighting outcomes and information both for the whole service but also elements of it. Its use involves the following processes:

- Identification of the elements of each collection service
- Use of common settings for each of the variable parameters relating to housing density, geography and housing type
- Standardisation of each component as a risk level per house
- Production of lifting and handling scores that can be extrapolated for individual analysis.

Outputs for the RCT are generated through a Microsoft Excel workbook, designed to factor in several criteria of which collection, transfer and landfill were within scope and allows for different systems to have all risks. It purports to measure risk in relation to waste collection.

This study created Manual Handling scores based upon studies by Pinder & Milnes (2002), Oxley et al. (2006) and Bomel (2009). Through inputting data, it was possible to compare how different elements of a service contributed to the whole level of risk as calculated by the risk comparator tool, by performing a cumulative numerical calculation of risk. The tool considered cumulative exposure for the organisation, whereas the operatives' exposure to risk is daily. The RCT, by definition (a comparator) was considered a qualitative method when compared with the other two quantitative methods. There are two outputs for Manual Handling, to capture both handling of the 'slave receptacle' (a wheeled bin to collect from households where a vehicle cannot access) and handling of the householder's receptacle for the 'slave receptacle' collect component. The tool also includes the chronic and acute effects of injuries and ill health that may result from reasonably foreseeable non-trivial hazards. To avoid inconsistency in interpretation and risk evaluation, the study used the combined total throughout (Turner et al. 2008).

User testing was undertaken using a single council's information for the whole service through inputting the collection data for one authority with their Service Manager. By using different input data, it was possible to understand the structure of the tool, establishing how the scoring worked and how some components were related to the number of houses included. Consistent application and interpretation of the results was required for reliability. This required a representative estimation of the 'distribution factors' (Appendix 1) that would be used throughout the process. By identifying the parameters such as set out rate (a figure that adjusts the baseline data assuming that not all households will present their waste or recycling), housing types and densities, it was possible to calculate a baseline set of information looking at the whole service.

Without the detailed geographical, demographical and knowledge of public participation in other districts, the same settings were applied throughout the whole process. This would also ensure that the only deciding factor in the risk calculation was the methods for each type of waste collected. This involved obtaining individual data for LAs as follows:

(i)   Details of the processes carried out i.e. type of service and frequency, which was obtained directly from the LA and through publicly available sources e.g. the website, with most authorities having detailed information on their waste service,

(ii)   Further contact with authorities was carried out to compare different recycling components, noting that different services collect recycling in two trips,

(iii)   Three authorities stated that they did not collect side waste,

(iv)   Details around the number of households within the district, which was gained from the most up-to-date UK statistics available (ONS 2013 and DCLG 2013),

(v)   Details of the tonnages processed as waste and recycling were gathered from Waste Data-Stream information/performance reports found on each authority's website (note that this data was provided by LAs to report recycling extracted from the residual waste stream to the Department for Environment, Food and Rural Affairs (Appendix 2).

The Microsoft excel workbook, was used in accordance with the instructions accompanying the research report (HSE 2010b). It was completed for each component inputting round data and selecting appropriate 'component' and 'subcomponent' (Appendix 3).

Once the data was inputted into the spread sheet, various outputs were available in the form of a workbook, summarised below:

- The tab marked *'control'* is the sheet where all inputs were made and where the overall 'output' risk scoring was obtained

- The tab marked *'Grouped ra hazard'* contained the handling output risk score from within the system – this was the figure used to compare the manual handling element (the focus of this study) in order to give a more appropriate comparison than the overall risk

- The tabs marked '*grouped ra component'* and *'grouped ra system'* were not necessary for this study

- Other tabs were generated for each of the systems under analysis.

In all cases, the sheet cross references numbers and headings to ensure full traceability between separate sheets was used. This latter stage involved extracting the manual handling scores obtained from the selected component under study. 'Handling output' obtained was divided by the total number of households to give a risk per household (RR (Risk Rating) = ∑Handling

Scores/Number of households). Subcomponent data was combined to calculate different risk rates for each service and was translated into a rating figure through use of the risk comparator tool for overall risk.

Comparison

The results from the above were evaluated taking into account both statistical and descriptive findings (Philips and Goodman 2004). Statistical evaluation was carried out using the statistical software package 'Statistical Package for the Social Sciences' (SPSS). There were no occurrences of SPSS indicating insufficient sample size due to the classification chosen.

With such a small sample number, visual inspection of graphical data was undertaken to identify any possible linear relationship. Statistical evaluation was based upon hypothesis testing and based upon 95% confidence levels (Garven 2011).

The study also needed to understand the strength of the correlation between the variables, risk rating, absence rates and APC. Correlation tests were applied as appropriate, with parametric data using the Pearson Correlation test and non-parametric using the Spearman Correlation test (McQueen & Knussen 2002 pp164-168). Mukaka (2012) states that a correlation of 0.9 to 1 is considered 'very high', 0.7 to 0.9 'high', 0.5 to 0.7 'moderate ' and 0.3 to 0.5 'low'. Cohen (1988) suggests that caution should be given when considering the significance of correlations. A correlation of 0.9 may be very low if one is verifying a physical law using high-quality instruments but may be regarded as very high in the social sciences where there may be a greater contribution from complicating factors. The choice between using Pearson and Spearman when comparing outputs from the RCT was initially unclear due to the nature of the information obtained. It was therefore decided to:
   a. Use Pearson where this study examines possible relationships between APC and average absence rates using appropriate reliable data,
   b. Use Spearman with both comparisons involving risk rating – due to the uncertainty as to what extent the risk comparator tool is an ordinal scale.
   c. SPSS was also able to identify whether correlation was significant at the 0.05 level.

3   Results and Findings

This process provides triangulation between self-reported pain, absence rates and risk rating as highlighted in Figure 3. Table 4 shows a comparison of the manual handling outputs and the number of households. This table shows the total manual handling score extrapolated from the output sheet and how it is converted into a risk score per household.

As well as general study data, Table 5 / Figure 4 compares the APC, absence rates and the risk score from the HSE's RCT (Turner et al. 2008). These three parameters are in effect a 'troika' of data, all being used to indicate and compare different ways of viewing the same problem. Comparisons were made with the data available between:

(i) Absence rates for MSDs were compared with APC for parts of the body excluding feet and headaches

(ii) The handling risk rating was compared with the APC excluding feet, headaches, ankles and lower leg

(iii) Absence rates for MSDs were compared with the handling risk rating.

Comparison between body-mapping (APC) and absence rates

Both sets of results were plotted against each other (Figure 5) together with comparisons using Pearson correlation tests. The scatter plot gave an R^2 of 0.664. Visually, as APC increases, the absence rate tends to follow.

The output results from SPSS (Table 6) suggest a 'High Positive' correlation. Without indication of parts of the body affected when there is absence due to MSDs, it is difficult to carry out a high level comparison of APC without corresponding absence rates.

This indicates that the relationship between self-reported pain and absence is statistically significant and that the identification and recording of self-reported pain is a good predictor of future MSD absence unless an intervention takes place. Data for both does have a high reliance upon self-reporting. Absence rates do not take into account individual pain thresholds and just reflect those away from work whereas APC is generated by surveying those staff at work.

Comparison between body-mapping (APC) and risk rating

Figure 6 compares the waste collection systems and shows the different effects of different components on the whole collection system. Boxed collections together with food waste

collection raise the risk levels significantly. At Authority 1 (2010), this was also affected by the effects of side waste accompanying the weekly collections of waste (140-litre wheeled bins) together with a relatively low recycling rate constrained with less than 90-litre of capacity per fortnight.

Both APC and RCT results were plotted against each other (Figure 7) and comparisons made using Spearman Correlation tests. The handling risk rating was compared with the APC excluding feet, headaches, ankles and lower leg. The scatter plot gave an R^2 of 0.776.

The output from SPSS gives a 'High Positive' correlation (Hinkel et al. 2003), Table 7, indicating that there is a (near significant) relationship between APC and Risk Rating. This suggests an expectation that the more physically demanding work systems chosen will manifest itself in employees feeling discomfort. It is possible that the results would have been significant had the sample size been larger.

Comparison between absence rates and risk rating

The final comparison was between absence rates (backs and MSD) and handling risk rating (RCT) using the Spearman Correlation Test . All the authorities who allowed body-mapping provided at least 12 months of absence information. It was expected that the highest APCs would come from authorities with higher absence rates.

The scatter plot (Figure 8) compares MSD absence rates with the APC excluding feet, headaches, ankles and lower leg, giving an R^2 of 0.84. Table 8 shows a weaker (Low -Medium Positive, 0.49) correlation (Hinkel et al. 2003). This is partially because of sample size and other factors (Figure 2), and warrants further investigation.

The relationship that appears visually strongest is the relationship between APC and Risk Rating (Figure 7). Figures 5 and 8 appear less linear due to the cluster of ill health absence rates for MSD pain of 4.2, 4.8 and 3.8 days per employee for similar activities. The significant reduction in MSD absence rates at Authority 1 after the change of service type (activity) between 2010 and 2012 is

not replicated with a corresponding reduction of other ill health absence rates (14.4 to 13.8 days/employee) indicating they are caused by non-work factors.

The HSE's risk comparator tool appears to produce higher scores for bags and boxes than wheeled bin collections. This method of triangulation aligns with the previous findings i.e. the 'risk' is confirmed by the real-life consequences. The correlation between APC and Absence Rates (MSD) risk rating (Table 6) is high at 0.85 using the Pearson Correlation (statistically significant) There was a slightly lower correlation at 0.77 between Service Risk Rating and APC (Table 7) and weaker correlation between Service Risk Rating and absence rates with a Spearman Correlation of 0.486 (Table 8). Whichever method of comparison is used, systems comprising 4-wheeled bins and 2-wheeled bins consistently appear to be less hazardous when compared with systems using sacks and boxes.

The outputs suggest that the method of work, including baskets, boxes and sacks, may affect the amount of absence due to both direct cause and as a barrier for early return to work (noting that 'other absence' is often higher for more strenuous work) due to a lack of 'light duties'. The weakest correlations were those with the RCT, mainly due to its design based on generic factors and that it is, by definition, a comparator tool.

Other Comparisons

When the same statistical comparisons were made for 'other absence' (non MSD related) no significant relationships could be found (Table 4). This suggests that a lack of granularity in high level data may mask the presence of specific risks. The study also looked for any effects of age and length of service with APC or absence rates. Older staff in one local authority were reluctant to declare their age; for the other LAs the average ages for those who disclosed were between 38 and 42. Pearson Correlations were very low when comparing APC with Average Age (0.23), low when considering APC with Length of Service (-0.43), Absence Rates v Average Age (0.48) and moderate when considering Absence Rates v Length of Service (0.54).

The study also compared risk rating with average age (low @ 0.43) and risk rating (medium @ -0.77) using Spearman. This final inverse relationship indicates that employees remain longer in work when it is less arduous.

4   Discussion

These findings have identified relationships between APC, physical risk factors and absence associated with different work, as suggested by Widanarko et al. (2011). The study has confirmed that it is possible to support theoretical data with real-life data (Borg et al. 2000) having compared field data with theoretical data and that obtained in lab experiments (Joshi & Deshpande 2019).

If it is assumed that absence only takes place when pain reaches a certain level (McGill 1997) then by using APC the whole workforce (aside from those absent at the time of the survey) are included in the analysis. If information is restricted to absence rates there is a greater self-selection process with those who have had no absence (but are still in pain) excluded.

When the HSE tool is used to analyse waste collection systems, it allows early contribution to the decision making process (McLeod & Cherrett 2008). It would therefore be expected that both the APC and, over a longer period, absence rates would reduce by a corresponding amount should a lower risk system be adopted. The study has confirmed that it is possible to predict the system of work likely to create the least ill health absence (Naylor 2014). Additionally, differences between Authority 1 (Set 2) and Authority 4 may be due to a decrease in collection frequency rates (Read & Mayne 2017). The study supports studies of Thomas et al (2019) and Thomas et al (2018) that if there is an increase in manual handling in services, this will lead to increased self-reported pain and absence.

When considering the interrelationships between APC and absence rates, the findings suggest four scenarios as follows:

- High APC and High Absence Rates (MSD) results suggest that there are long-term work related issues creating employee pain, including handling and throwing bags, handling boxes and baskets and vehicles with poor ergonomics (Zare et al 2020). Shifts are of increased length, with exposure to harmful system(s) of work with insufficient breaks and/or rushing of work (Otto & Scholl 2011). Containers may be full and at maximum weight possibly due to infrequent collections (Frew & Breheny 2020). This is reflected in the outputs from Authority 1 (Set 1) and Authority 5.

- High APC, Low Absence rates (MSD) results suggest that the system of work has changed over the last five years to a system predominantly using wheeled bins to accommodate an ageing workforce (Dianat et al 2020). This workforce may include those with previous lengthy exposure to harmful system(s) of work and/or with a history of non-work related lifestyle problems (Yassierli 2017). Work activity is likely to use wheeled bins and vehicles with good cab ergonomics promoting sustainable work (Herrera & Heras-Rosas 2020 and Schibye et al 2001). This is reflected in the outputs from Authority 2, an experienced workforce with the service having moved from boxed collections.

- Low APC, High Absence rates (MSD) results suggest that the information requires further interrogation with problems accurately classifying absences or obtaining data with spurious reasons for absence. It is possible that there were effects of significant periods of absence amongst a few staff, operations and/or traumatic injuries (Thomas et al. 2019) as well as legacy issues, employing staff with existing health conditions. There may also have been long shifts with insufficient breaks and/or rushing of work (Emmatty & Panicker 2019). This is reflected in the outputs from Authority 3 that require follow up in-depth intervention.

- Low APC, Low Absence Rates (MSD) results suggest that the system of work is established and predominantly wheeled bins having designed out the risk factors (Zare et al 2020) with modern vehicles with good cab ergonomics (Thomas et al. 2018). The workforce is either young or without lengthy exposure to harmful system(s) of work nor a history of non-work related lifestyle problems This is reflected in the outputs of Authority 4 and Authority 1 Set 2.

Of particular interest are the differences between the two sets of data from Authority 1. Changing from a system that was predominately 35-50-litre containers for recycling to a 240-litre wheeled bin saw a reduction in absence rates (8.9 to 3.8 days off/employee for MSDs) and for self-reported pain excluding lower legs, feet and headaches (APC 3.8 to 1.8), supporting the work of WYG (2011). This coincided with a reduction in the 'Handling Risk Score' from 2.7 to 1.6 (HSE 2010b). Unfortunately, the inclusion of Food Waste Collection in small containers at the same time (Pinder & Okunribido 2019) and the re-survey within six months of the change to the survey meant that there was no opportunity to evaluate the effects of a single ergonomic intervention (Zare et al. 2020). This also coincided with a change in recycling rates at Authority 1 (Kennedy

2013) from 25% to over 50% (between 2010 and 2013), which indicates that it is possible to increase recycling rates and reduce ill health rates (HSE 2010a).

Identifying systems of work with predicted lower risk scores using the RCT could be used to maximise employability when rehabilitating people back into work who been absent from work due to health reasons and receiving benefits (Black and Frost 2011). This may help organisations manage the challenge between 'worker capability' and equality legislation (UKG 2010) with regards to age discrimination . By redesigning a service maximising the use of wheeled bins, operations managers can utilise a workforce previously exposed to a less 'ergonomic-friendly' service, such as one involving handling boxes and baskets such as in the case of Authority 2 (Schibye et al 2001).

Indeed, when comparing length of service with system design (risk rating) there appear to be advantages in operating more sustainably (Herrera & Heras-Rosas 2020) with average length of service of almost 10 years in Authority 2. Their Operations Manager indicated that staff turnover reduced significantly once the service had moved to wheeled bin collections a few years previously.

The findings from this study will help to move the focus to the association between methods of waste collection and MSD ill health (Emmatty & Panicker 2019). Teiger (1996) discusses how a paradigm shift takes place once industry has moved on from "association to causation". Use of such tools is something that still needs to be promoted, especially as some nations are starting to develop and upgrade their recycling strategies (EBRD 2017).

Use of such a tool has been a challenge to an industry that struggles with change due to management factors and management competency factors (EU Skills 2010). This tool does appear cumbersome due to the size of the report describing its use and the practice needed prior to use. Having a system of work that creates minimal MSD ill health is also vital when considering rehabilitation following injury or ill health. In order to promote efficient and effective recovery, it is important to remove the employee from the activity that is considered the cause of the problem (McGill 1997).

Despite the evidence and benefits of authorities moving to systems that eliminate kerbside boxed collections and sorting, the literature also identifies other non-safety benefits such as reduced costs and increased recycling (Potter 2012). It is counter-intuitive that other authorities are going in the opposite direction removing glass from co-mingled wheeled bins systems and installing inserts in wheeled bins requiring lifting or twisting or separate boxes.

Although there was moderate correlation between length of service and absence rates, we noted some staff interpreted this as duration in their current role rather than time in waste collection, hence building in 'legacy' issues (e.g. a loader moving into a driving role). This supported the development of the model developed by Thomas et al (2018).

The limitations were two-fold. Firstly, the difficulty in getting LAs to participate with concern that such a study may 'unsettle' the workforce in a sector that has management challenges together with data protection issues. Conversely, worker participation was affected by trust with regards to where the information was going; this was reflected in some staff in one authority being reluctant to give their age despite assurances around data protection and the independence of the researchers. The large waste collection contractors refused to engage, equally concerned that LAs would not approve of such engagement, resulting in significant data not becoming available.

5   Conclusions and Recommendations

Conclusions

The aim of this study was to examine the manual handing element of the HSE risk comparator tool through comparison with ill health absence data and self-reported pain through body-mapping for a number of LAs. Ill health data was difficult to obtain and very often not in a form allowing for a more detailed comparison with APC to be made.

This is the first study of its kind by comparing both individual absence data and system based risk rating. It is also the first study comparing the manual handling elements from the HSE tool and evaluating the simplicity of the tool. Although relatively simple to use, the user needs to break the service into distinct components and to ensure that the 'factors' are consistent across all

services under comparison. It is therefore vital to break information down into data that can be compared like for like in order for studies to be carried out.

Comparison between APC and MSD absences shows significant correlation at the 0.05 level using Pearson although this has not been broken down to compare parts of the body affected. Comparison between both APC and MSD with the outputs of the RCT per household using Spearman suggests less of a relationship. Use of RCT, a non-parametric correlation test, may have understated the outputs as both comparisons had high R^2 values. The study suggests that use of the HSE tool does provide a level of validation through triangulation although more studies of this type are needed.

The main implications for theory and practice are that the HSE tool can be used as a predictor of MSDs arising out of a service and be used as a first step to cost model service options, however the APC appears to be a better predictor of MSD absence than the HSE Tool. The study suggests that the elimination of manual handling with the elimination of both bagged and boxed collections, together with kerbside recycling should be the primary control measure and considered as a reasonable adjustment. Data from Authority 1 suggests that separate food waste collection using caddies may increase the amount of MSDs.

The study has identified associations using three methods between the development of MSDs and the type of collection system. Although not all the results were statistically significant, each of the three tests show that operatives who correctly use wheeled bins are least likely to have MSDs suggesting that this in itself is significant. From an epidemiological perspective, the results identify an association between collection methods and the prevalence of MSDs. The RCT is a high level strategic risk tool and by design insufficient in responding to confounding factors such as operative age or length of service whereas, when comparing APC with absence rates, such differences are built in, thereby providing greater insights to the risks involved.

This study should be seen as a catalyst for employers in the waste industry to move their focus away from managing the effects of ill health to minimising the causes of MSD ill health in the first place and having systems of work that are accessible to an ageing workforce. The study highlighted the importance of worker engagement although some LA managers were not

prepared to allow access to their workforce because of the fear of uncovering complex systematic health problems that could be too difficult to resolve.

Recommendations

Following this study, a number of recommendations have emerged:

(i)   As all waste collection activities create risk, there should be a coordinated effort to minimise the volume of household waste requiring collection.

(ii)   Wherever possible wheeled bins should be used in preference to smaller containers and loose bags.

(iii)   LAs should use the RCT to compare system options prior to commencing any tendering process and to inform intervention strategies for MSDs.

(iv)   LAs, as clients, should seek to eliminate manual handling wherever possible to make collection as sustainable as possible, especially with regards to the collection of food waste, and to embrace new technologies that lower the exposure to MSD risks.

(v)   With this study being repeatable, further studies including body mapping and industry absence rates should be obtained so as to compare APC and MSD absence for comparison with the RCT; including capturing any legacy issues arising out of previous roles.

(vi)   Although the RCT gives a good insight into the effects of different collection systems, it requires a review so that it can become easier to use for decision makers to adequately evaluate the options available.

(vii)   In the absence of reliable HR data, body-mapping should be used as a proxy method of assessing MSD risk.

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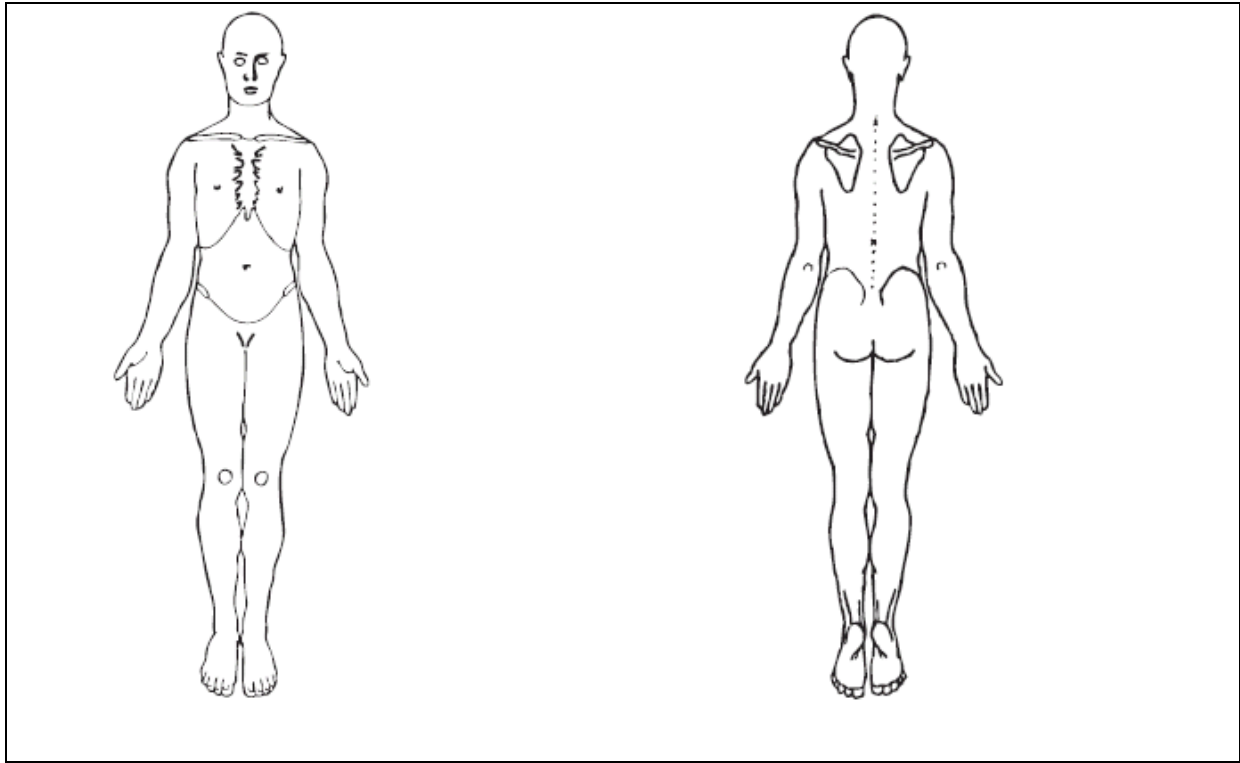
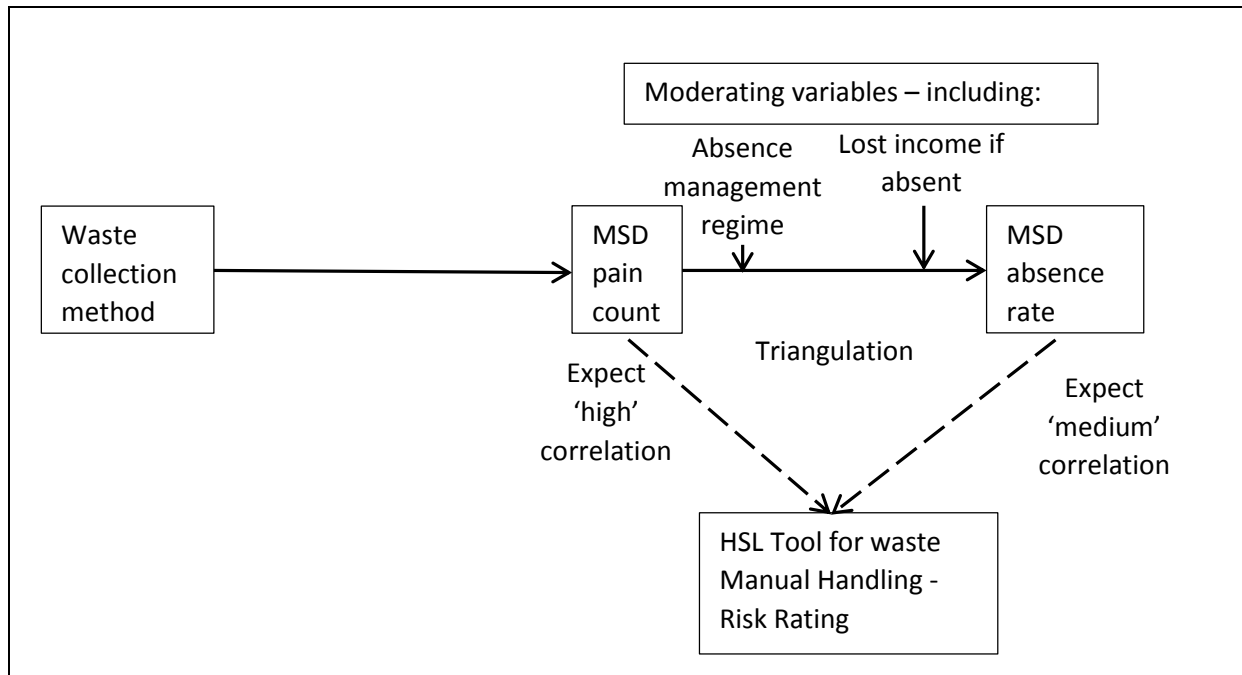**Figure 1 Specimen Body Map Charts (after SOR 2007)**

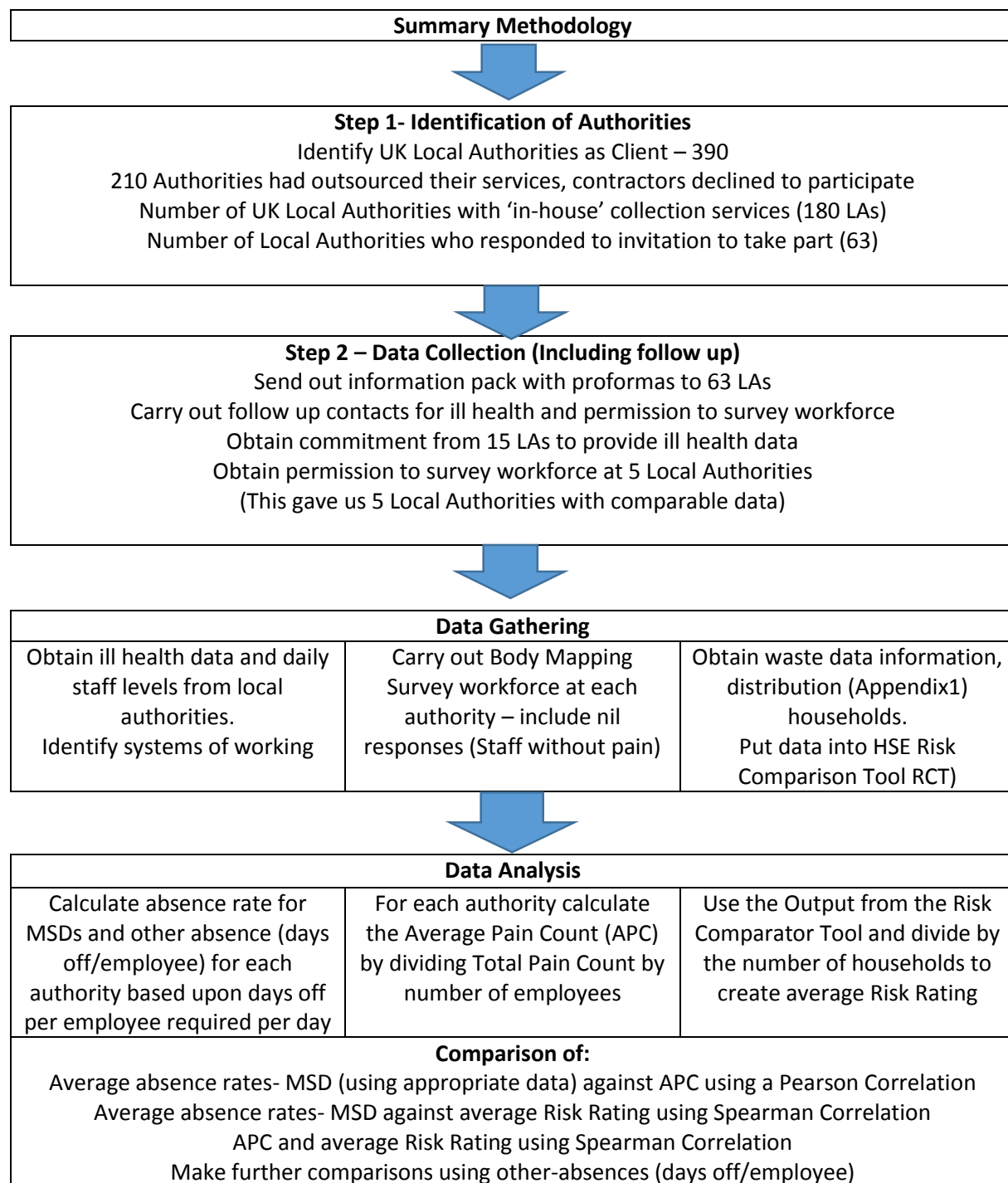**Figure 2 Study Framework (Author)**

Summary Methodology

⬇

Step 1- Identification of Authorities Identify UK Local Authorities as Client – 390 210 Authorities had outsourced their services, contractors declined to participate Number of UK Local Authorities with 'in-house' collection services (180 LAs) Number of Local Authorities who responded to invitation to take part (63)

⬇

Step 2 – Data Collection (Including follow up) Send out information pack with proformas to 63 LAs Carry out follow up contacts for ill health and permission to survey workforce Obtain commitment from 15 LAs to provide ill health data Obtain permission to survey workforce at 5 Local Authorities (This gave us 5 Local Authorities with comparable data)

⬇

Data Gathering		
Obtain ill health data and daily staff levels from local authorities. Identify systems of working	Carry out Body Mapping Survey workforce at each authority – include nil responses (Staff without pain)	Obtain waste data information, distribution (Appendix1) households. Put data into HSE Risk Comparison Tool RCT)

⬇

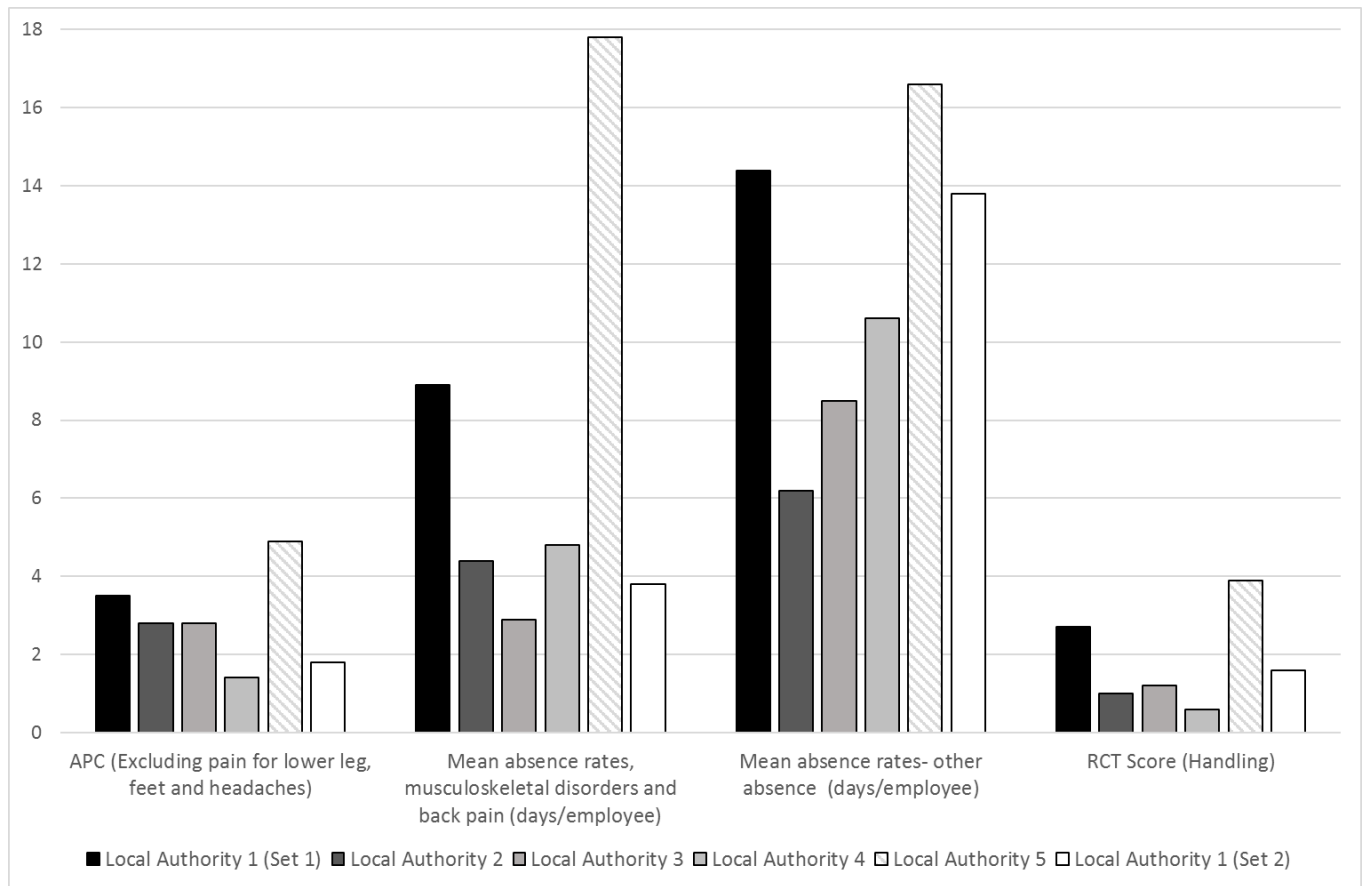| **Data Analysis**		
Calculate absence rate for MSDs and other absence (days off/employee) for each authority based upon days off per employee required per day	For each authority calculate the Average Pain Count (APC) by dividing Total Pain Count by number of employees	Use the Output from the Risk Comparator Tool and divide by the number of households to create average Risk Rating
Comparison of: Average absence rates- MSD (using appropriate data) against APC using a Pearson Correlation Average absence rates- MSD against average Risk Rating using Spearman Correlation APC and average Risk Rating using Spearman Correlation Make further comparisons using other-absences (days off/employee)		

Figure 3 Methods Used Flowchart

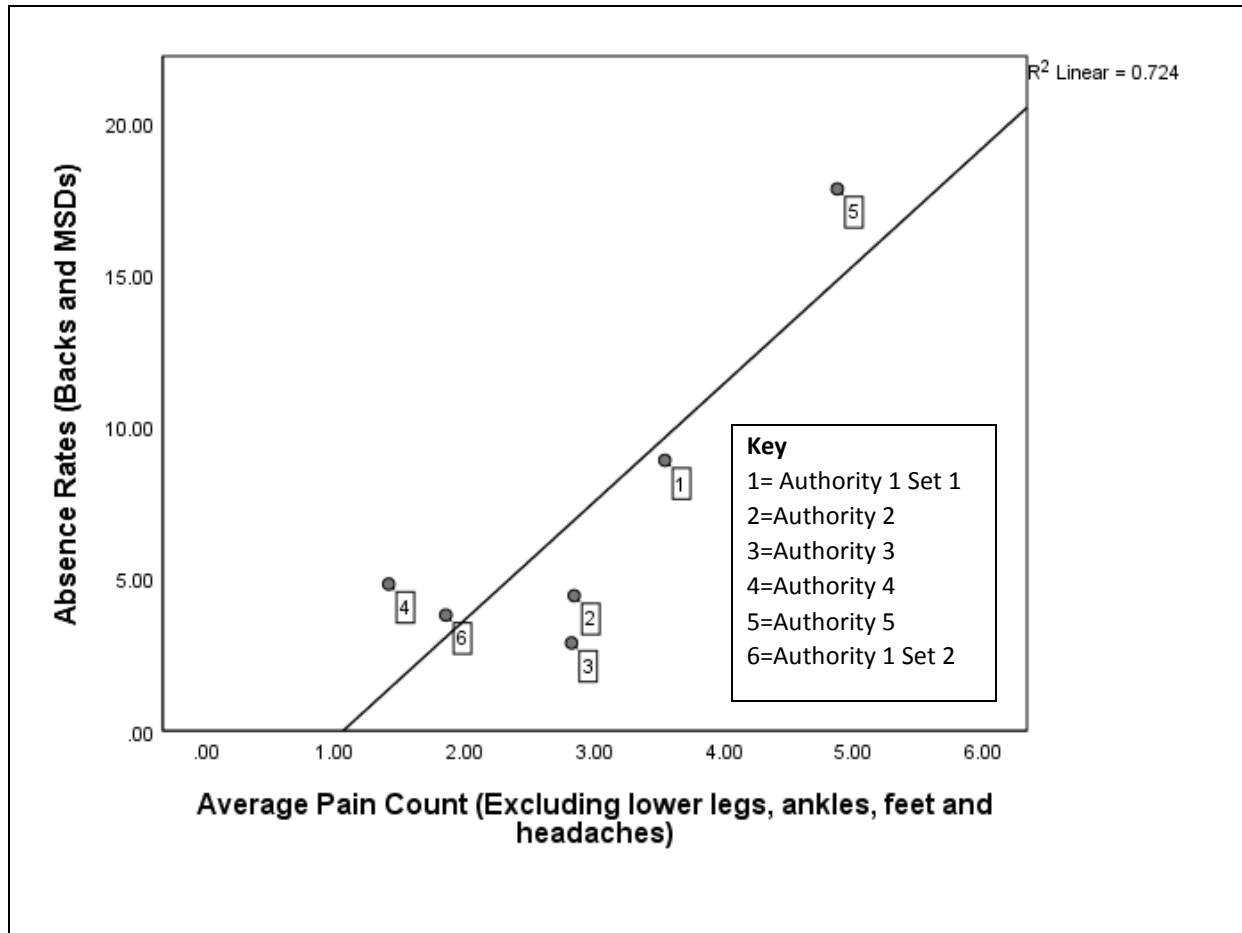**Figure 4 –Comparison of Local Authority Outputs (From Table 5)**

Figure 5 Comparison between Absence Rates and Average Pain Count
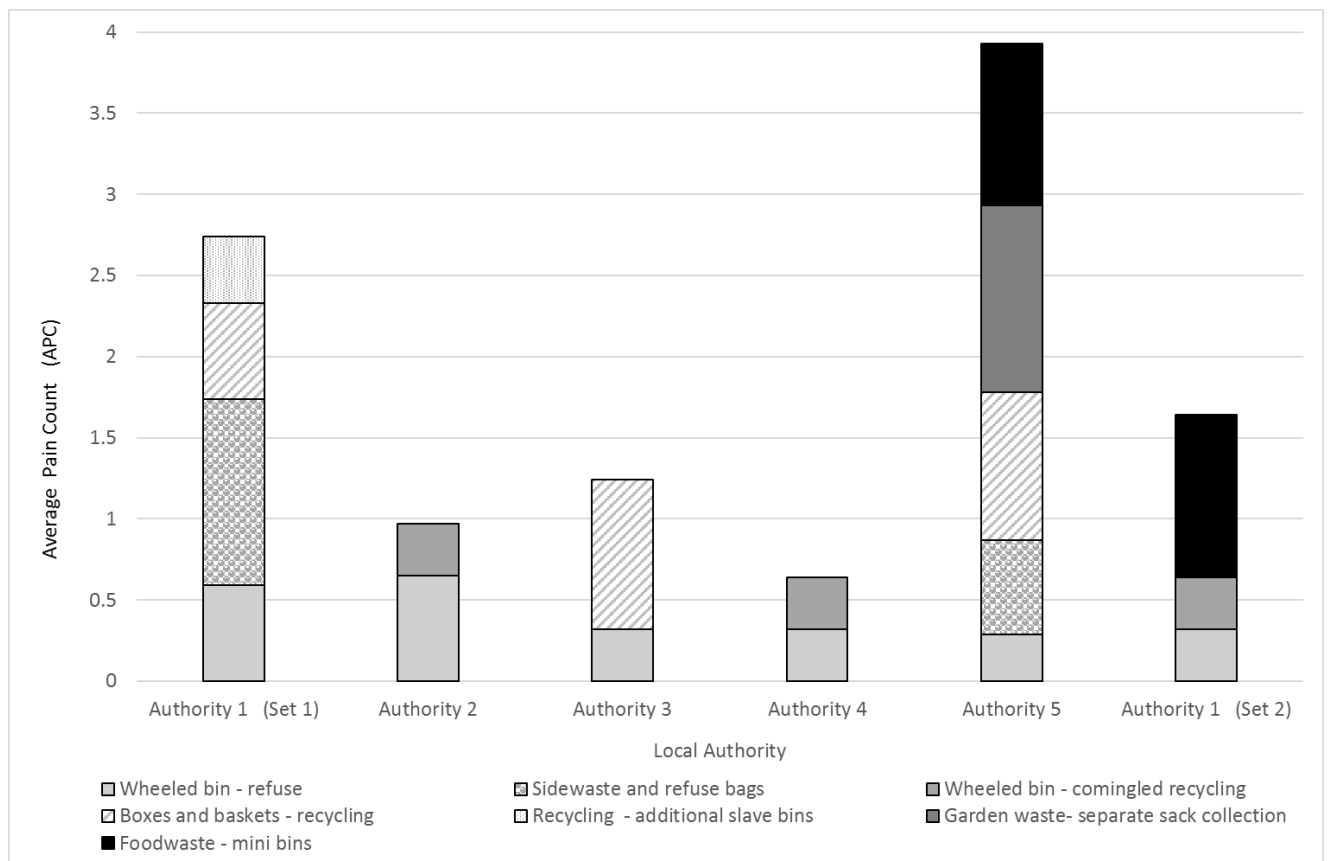
Figure 6 Comparison of Risk Rating (Handling) –Components known at 31.01.12 (From Appendix 3)
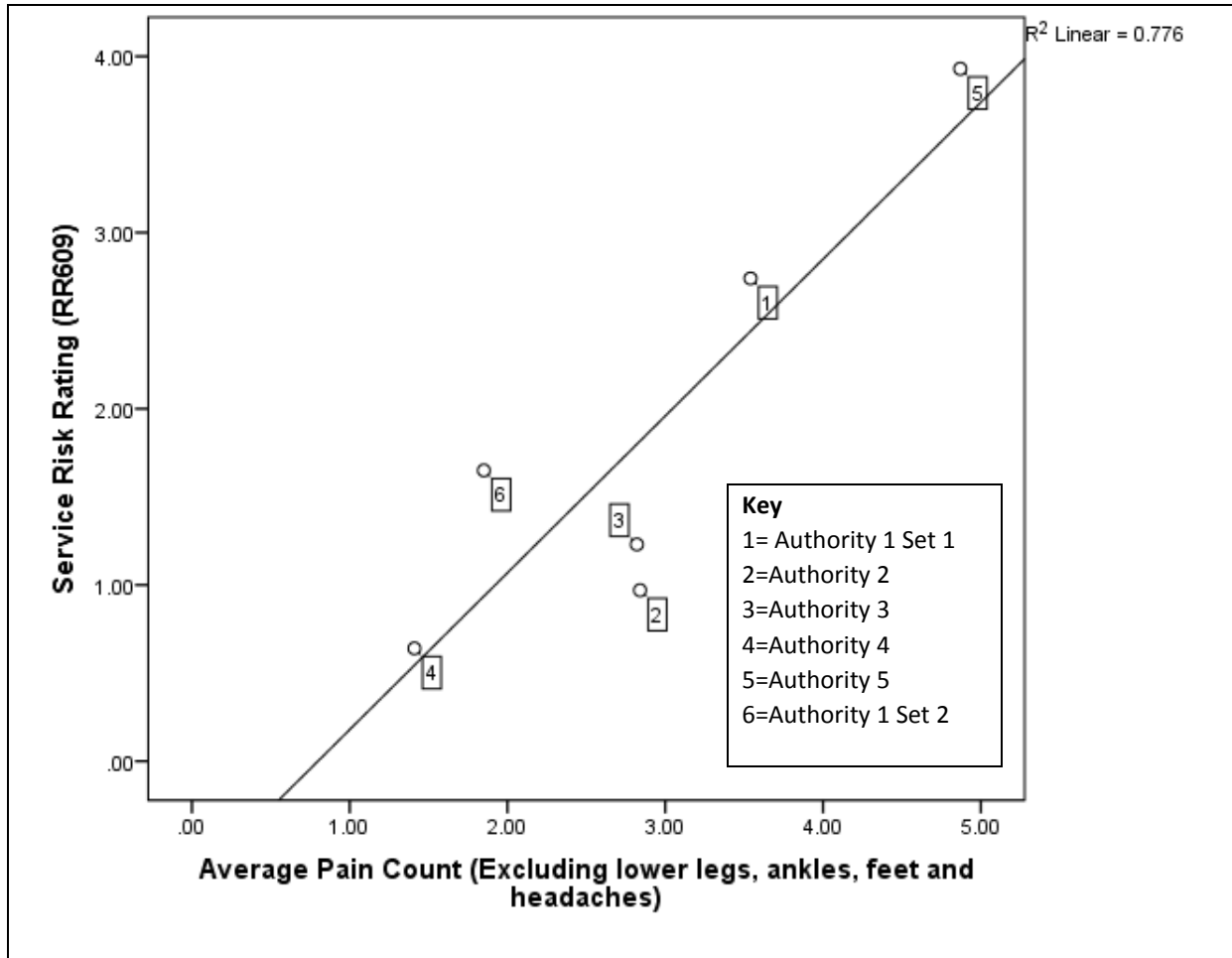
Figure 7 Scatter Plot comparison between Service Risk Rating (RCT) and Average Pain Count
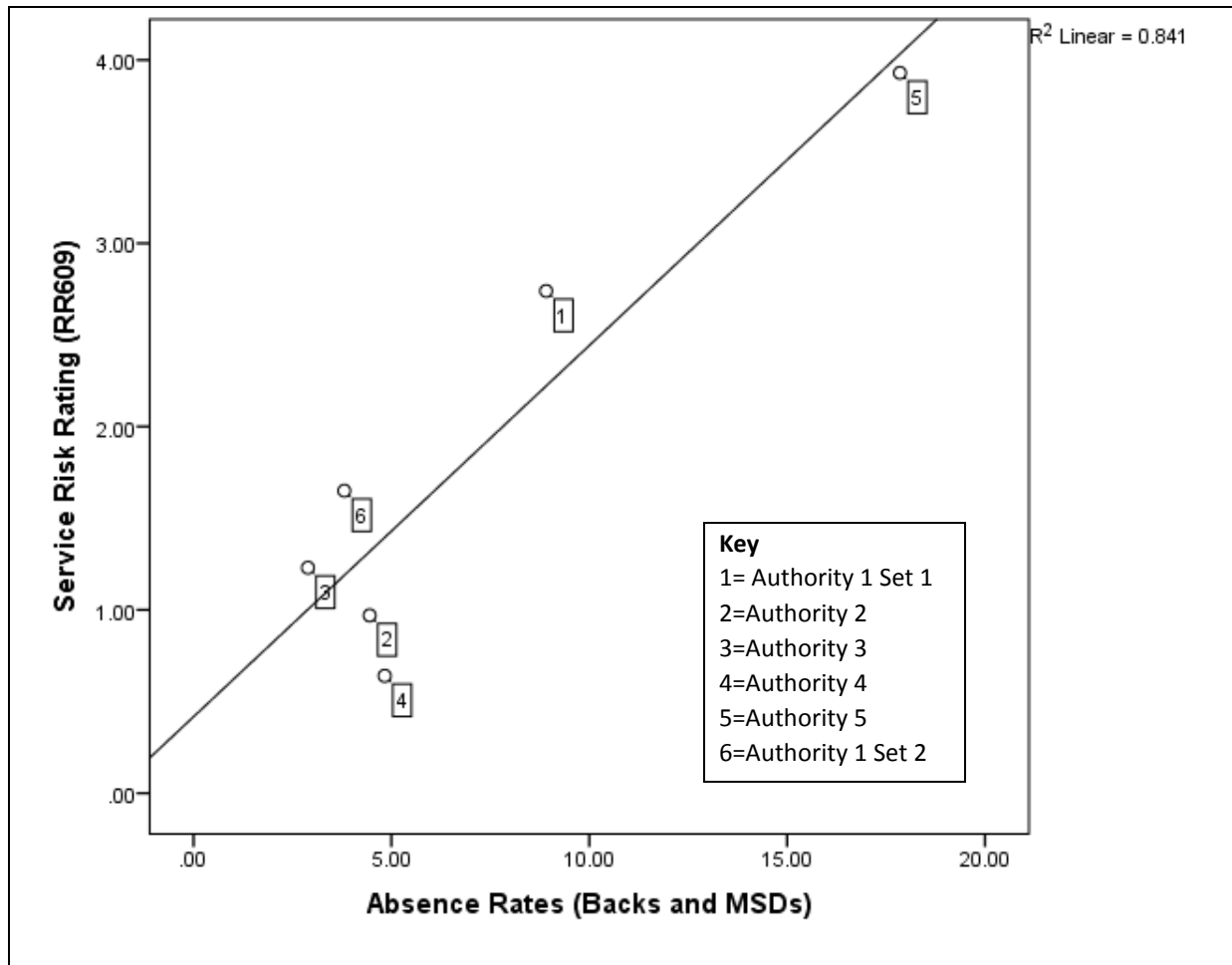
Figure 8 Comparison between Service Risk Rating (RCT) and Absence Rates

Table 1- Summary of parts of the body affected by waste collection after Thomas (2005)

Typical Activity	Parts of the upper body affected			
	Neck	Shoulder	Elbow	Back
Pushing and pulling wheeled bins (120-360 litres)	No	Yes	Yes	Yes
Handling of plastic sacks	No	Yes	Yes including throwing	Yes, including bending down to pick up
Handling boxes and baskets (30-45 litres)	Yes	Yes	Yes	Yes
Handling food waste containers (20 litres).	No	Yes	Yes	Yes
Filling secondary wheeled bins from other containers	Yes	Yes	Yes	Yes including bending down to pick up and lifting to tip into wheeled bins
Handling trade bins(660-1200 litres)	No	Yes	Yes	Yes

Table 2 Demographics of participating Local Authorities

Local Authority	Region	Geography	Summary of Collection Systems when study carried out (See Figure 4)			No of Staff Surveyed	% Participation	Average Age (years)	Average Length of Service (years)[Note 4]
			Residual Waste	**Recycling**	**Food waste**				
1 (Set 1)	South East England	Urban and Rural	Wheeled Bins (sacks ; residual waste [Note 3])	Baskets Boxes Slave Bins	No	70	96 [Note 1]	38.42	6.20
2	South East England	Urban	Wheeled Bins	Wheeled Bins	No	44	61	42.22	9.37
3	East Midlands	Urban and Rural	Wheeled Bins	Boxes	No	35	75	31.76 [Note 2]	5.86
4	South East England	Urban and Rural	Wheeled Bins	Wheeled Bins	No	59	100 [Note 1]	39.42	7.24
5	South East England	Urban and Rural	Wheeled Bins (sacks ; residual waste [Note 3])	Boxes Sacks -Garden Waste	Yes, small caddy	60	78	41.72	4.75
1 (Set 2)	South East England	Urban and Rural	Wheeled Bins	Wheeled Bins (Including Garden Waste)	Yes, small caddy	54	71	38.25	5.88

Note 1- this rate was achieved due to the survey being done on a number of days and included staff covering absence

Note 2 – some staff were reluctant to declare their age or length of service on the survey therefore no statistical analysis practically available

Note 3 – LA policy was to collect any residual waste presented in sealed sacks; sacks normally thrown into the rear of the refuse collection vehicle

Note 4 – this is length of time working for the authority and not the role surveyed against (their current work activity)

Table 3 – Feedback from users (Turner et al 2008)

Use of the tool	Other Observations
• It can be used to calculate relative risk and for comparison rather than against a zero base line	• Many of the factors are fixed and consequentially the LA cannot change them
• Outputs can be affected by number of houses serviced, so risk level 'per household' should be used	• Additional filtering is needed to compare different collection systems carried out by each authority due to the holistic nature of the tool
• It is difficult to build in the effects of mixed collections – a need to put into components and, due to recording information available, very difficult to separate components when all recycling details are combined.	• The tool could also be used to examine specific risk components such as manual handling or slips and trips.
• It allows for food waste collection to also be considered.	

Table 4 Output from HSE Risk Comparator Tool –Risk rating per household

Authority	Handling Risk Score = a	No of houses = b	Risk Rating= a/b
1 (Set 1)	194239	71024	2.73
2	72735	74926	0.97
3	44457	36000	1.23
4	37536	58360	0.64
5	218423	55582	3.93
1 (Set 2)	117242	71024	1.65

Table 5 APC comparison with risk score and absence rates.

| | Local Authority | | | | | |
| Date | 1 (Set 1) | 2 | 3 | 4 | 5 | 1 (Set 2) |
	2010	2011	2011	2011	2011/12	2013
No of Participants	70	44	35	59	60	54
APC All	4.5	3.9	3.5	1.6	5.7	2.3
APC (Excluding pain for feet and headaches)	4.0	3.2	3.3	1.5	5.3	2.1
APC (Excluding pain for lower leg, feet and headaches)	**3.5**	**2.8**	**2.8**	**1.4**	**4.9**	**1.8**
Mean absence rates (pooled data) musculoskeletal and back pain	**8.9**	**4.4**	**2.9**	**4.8**	**17.8**	**3.8**
Other absence rates	14.4	6.2	8.5	10.6	16.6	13.8
Risk Score (Handling)	**2.7**	**1.0**	**1.2**	**0.6**	**3.9**	**1.6**

Note –
- "mean" - refers to corresponding years of absence
- bold signifies outputs statistically compared

Table 6 Correlation Testing (Pearson) Between Absence Rates and Average Pain Count (APC)

		APC (excluding lower leg, feet and headache)
Average Pain Count (APC)	Correlation	.851*
	Sig. (2-tailed)	.032
	N	6

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7 Correlation testing (Spearman) between Risk Rating and Average Pain Count (APC)

		APC (excluding lower leg, feet and headache)
Risk Score	Correlation	0.771
	Sig. (2-tailed)	0.072
	N	6

Table 8 Correlation Testing (Spearman) between Absence Rates and Risk Rating.
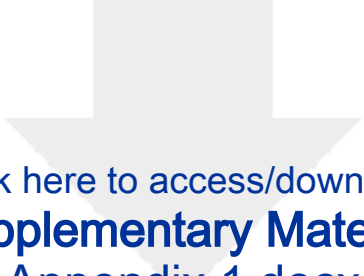
		Mean absence rate
Risk Score	Correlation	.486
	Sig. (2-tailed)	.329
	N	6

A Comparison of Manual Handling risks in different Domestic Waste Collection systems using three separate evaluation methods
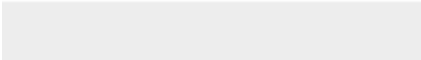
Conflicts of Interest
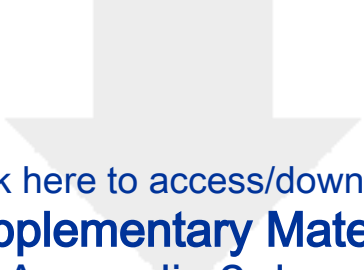
There were no conflicts of interest involved in this study declared by any of the authors. The study was self-funded and the study was independent from the influence of any government body, company or trade body.

Dr David Thomas
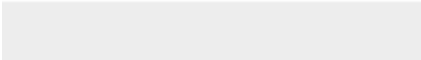
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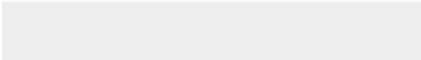**Supplementary Material**
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