Appendix A

In this screen of the interface, the first task of the designed job is entered. This could be one of the 13 tasks most common to commercial office janitorial work and included in Table 5. These are the tasks that were observed in the field data collection phase.

The task descriptions offer more detailed explanations about the listed tasks and they appear as “Control Tip Text” to help the user understand the task names used in the calculator. This is done by placing the mouse cursor over the field and the text will appear. This method is used in all the fields of this data entry screen.

Figure 6. Data entry screen

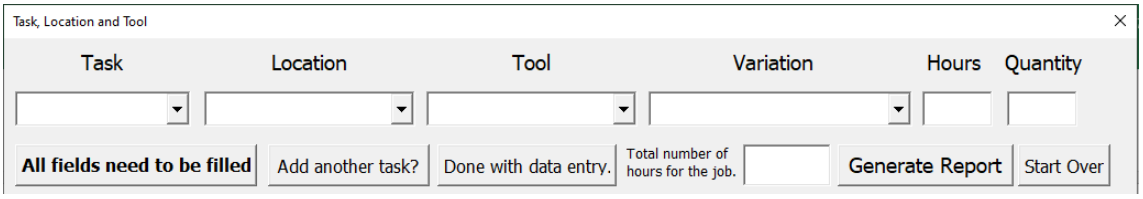


Table 5. Currently available task list together with their descriptions

Task	Task description
Check and replace dispensers	Checking and refilling soap dispensers
Cubicle cleaning	Cubicle cleaning, multiple tasks including dusting, trashing, wiping
Damp mopping	Damp mopping
Dust mopping	Dust (dry) mopping
Dusting and wiping	Dusting and wiping
Elevator cleaning	Elevator cleaning, multiple tasks including dusting, wiping, and vacuuming
Glass door cleaning	Glass door cleaning
Locker room cleaning	Locker room cleaning, multiple tasks including dusting, trashing, wiping, mopping
Restocking supplies	Restocking multiple restroom supplies including toilet papers, paper towels, seat covers, soap
Restroom cleaning	Restroom cleaning, multiple tasks including dusting, trashing, wiping, mopping
Scrubbing	Scrubbing
Trashing	Trashing
Vacuuming	Vacuuming

After selecting a task, the user must select a location. For example, dust mopping task has two different locations to choose from: 1) hard floor, and 2) reception/lobby/elevator. Vacuuming task has seven different locations to choose from: 1) carpet, 2) carpet/hard floor, 3) elevator, 4) hard floor, 5) office/cubicle, 6) stairways/landings and 7) walk-off mat.

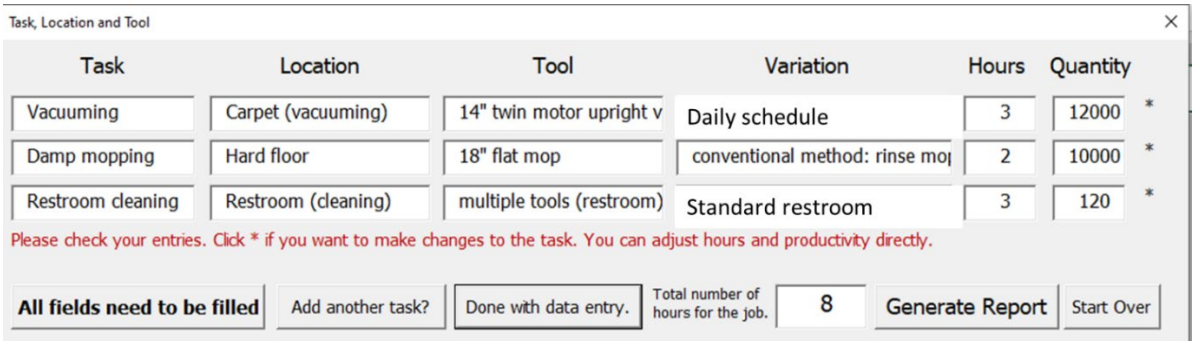
The corresponding tools used for the task at the specific location will then be selected. If there are differences under the same task, location and tool, they are listed under the "variation" field. As mentioned, this could be situations that may affect the workload, such as different work techniques, different frequency of cleaning specified in the contract, and special arrangement of the office building. It's again important to note, that our variations field reflects our limited worksite visits. However, the calculator has been designed to be flexible for future updates if additional variations emerge.

After the four task-related parameters are entered, the user enters the number of hours that is to be allocated to the task and the associated production rate or total production goal (e.g. number of small trash cans to be emptied).

After the first task information is entered, the user continues the same process to add additional tasks to the job until the whole shift is filled. Figure 7 demonstrates one example of the task list of a newly designed job.

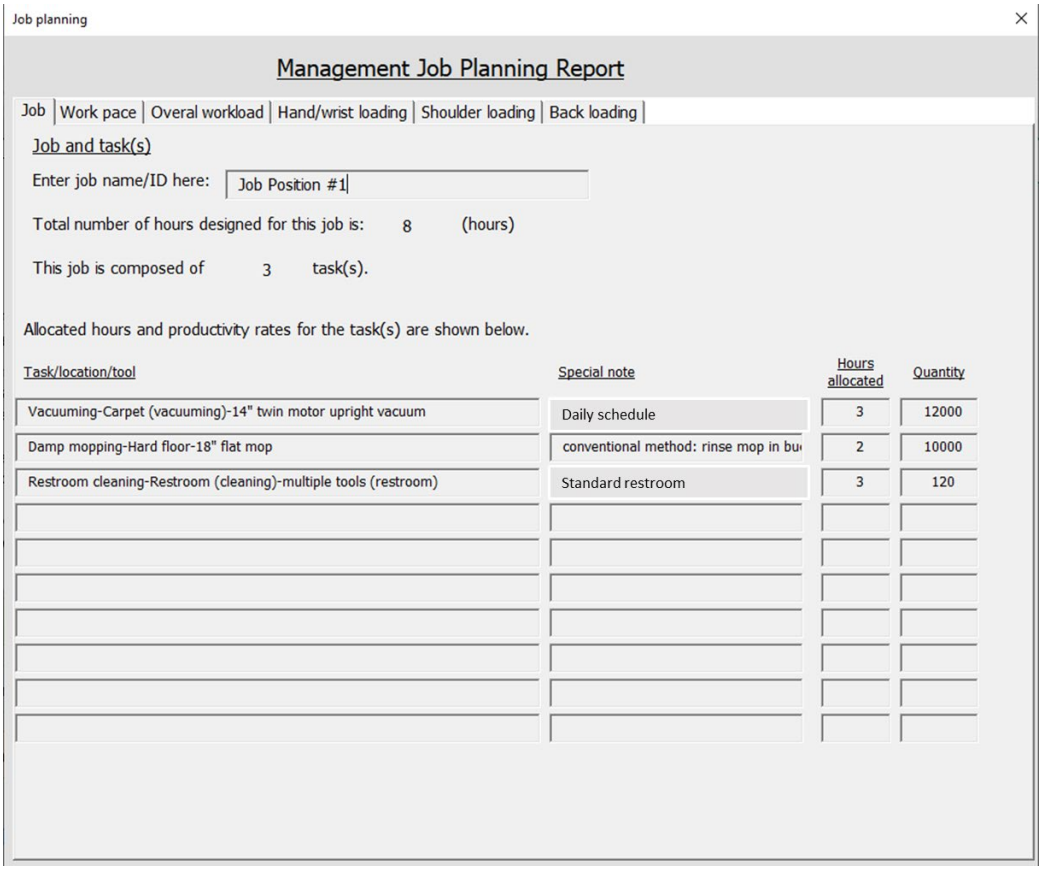
This example job has three tasks: 1) vacuuming 12,000 square feet carpet with a 14" twin motor upright vacuum machine, with three hours for this task, 2) damp mopping 10,000 square feet hard floor using a 18" conventional rinse mop, with two hours for this task, and 3) restroom cleaning in a number of standard restrooms with a total of 120 fixtures using multiple tools, with three hours for this task.

Figure 7. An example of a new job design including 3 different tasks in an 8-hour work shift.



The "Generate Report" button shows designed jobs. The first tab of the reports is the job information that the user entered in the task data entry screen (Figure 7). In this report, the user can also give newly designed job a name (e.g. Job Position #1).

Figure 8. Report example: Job Position #1.



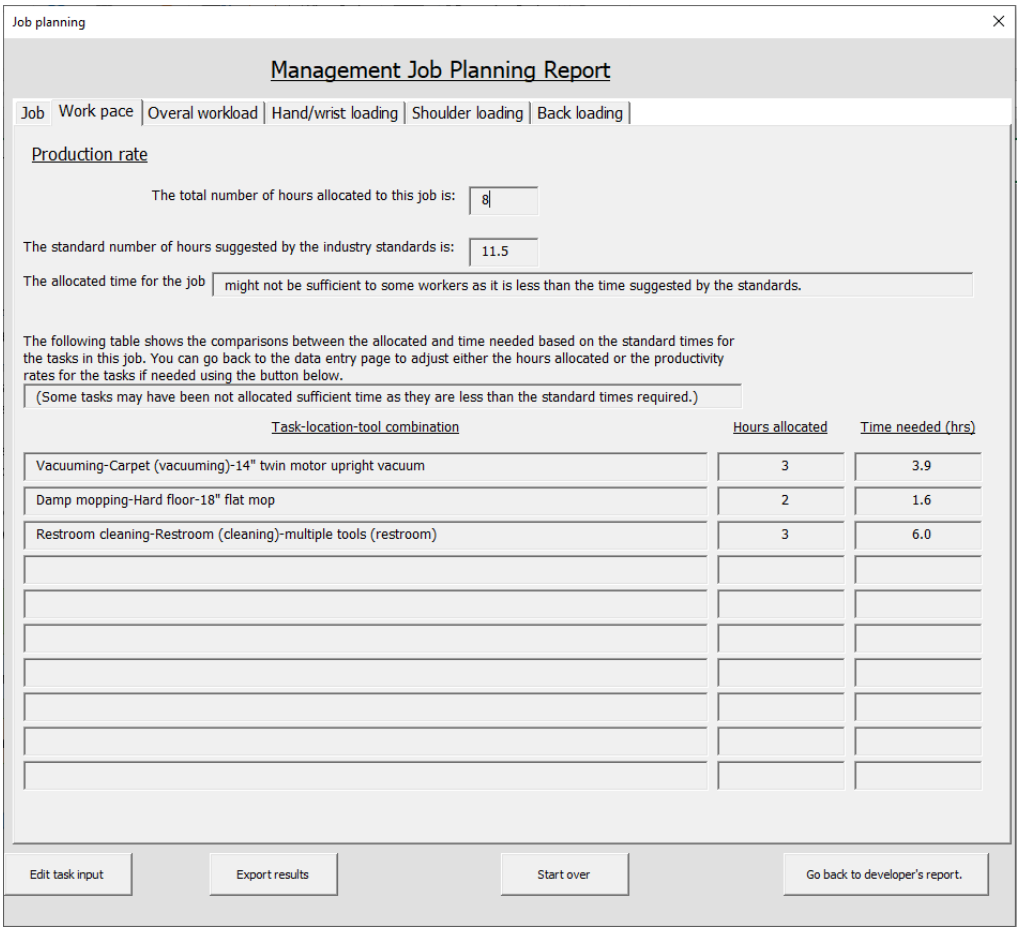
The next tab is the report of work pace (Figure 9). Here the work pace of the designed job is calculated according to the allocated hours and assigned quantity of cleaning for all the tasks. This is compared to the standard times (ISSA 2021) of performing these tasks.

At the job level, the total numbers of hours allocated to the job is compared to the total time needed for the job according to the industry standards. In the table shown, the comparisons of the allocated hours are compared to the standard times for the individual tasks. In our current example, according to the standard time,11.5 hours are needed to complete the job. However, the allocated time is only 8 hours. This shows the average healthy janitor will not be able to complete the tasks in the allocated time.

The detailed table for the tasks indicates that the industry standard specifies six hours are needed to complete the restroom cleaning task, but only three hours are allocated. Therefore, changes made to the job should include providing sufficient time for completing this restroom cleaning task, or reducing the work to match the time allotted.

The user can adjust the job design by clicking the “Edit task input” to navigate back to the data entry screen, where they can either lower the quantity of the assigned task or add more time to the task so that the work pace for the specific task can be improved.

Figure 9. Report example: Work pace



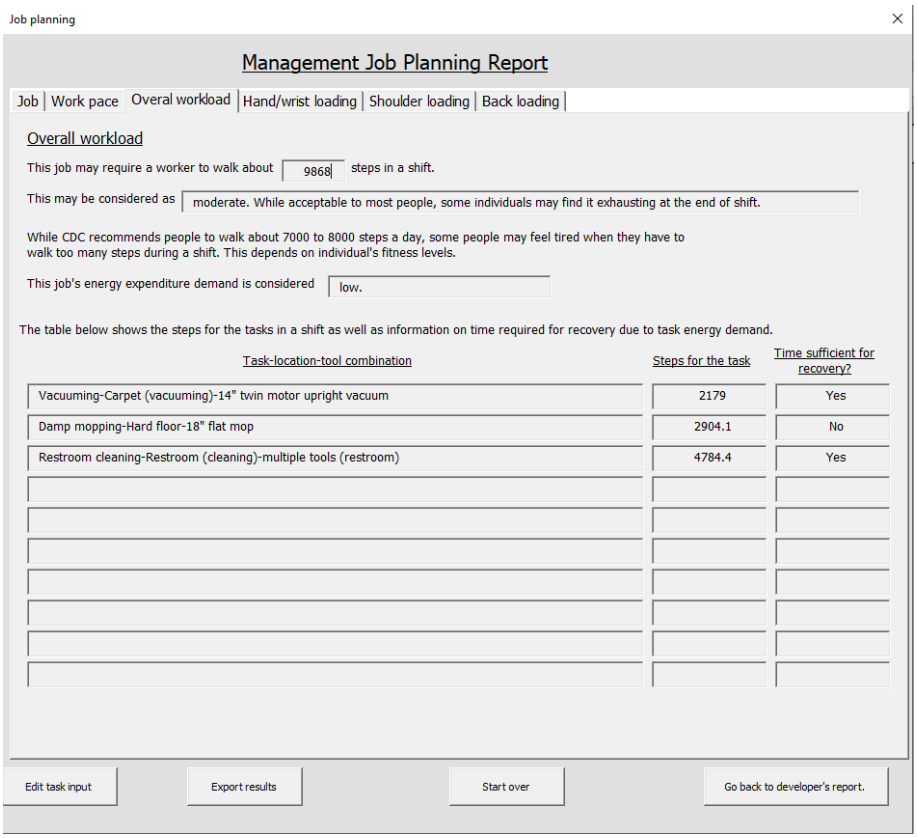
The next tab is labeled Overall Workload (Figure 10), measuring 1) the number of steps walked in the job as well in individual tasks, and 2) overall job energy expenditure demand, and energy expenditure demand of individual tasks of the job. The number of steps gives the requirements of walking, dependent on individual fitness levels. Although there are no guidelines on walking limits, some may feel exhausted due to lower extremity fatigue from long distances in a work shift. This information provides managers/supervisors quantitative data on walking steps of the job and tasks to make informed decisions if complaints of lower extremity fatigue arise.

The job energy expenditure demand is calculated from the heart rate data of the individual tasks. Using the task heart rate data collected in the field, individual participants' resting heart rates and their ages, the percent of heart rate reserves (%HRR) were calculated (indicating how hard the task is in terms of energy expenditure demand). The %HRR is then used together with the number of hours working on the assigned task to estimate the maximum acceptable work time using a formula suggested by Wu and Wang (Wu & Wang, 2002).

Our example job (Figure 10) shows that the total steps of this job is close to 10,000 steps with most walking steps (4784) occurring in the restroom cleaning task. While the overall energy

expenditure demand for this job is relatively low, the damp mopping task may have higher energy expenditure demand.

Figure 10. Report example: Overall workload



Next, there are three tabs on loading in three body regions: hand/wrist, shoulder, and back. The loading is related to the risk of developing work-related musculoskeletal disorders in those body regions. For the hand/wrist, the risk level is evaluated using the Revised Strain Index (Garg et al., 2017b).

Beyond hand exertion levels, frequency and duty cycle, and hand/wrist postures, task durations are used in the calculation of risk levels, identifying main contributors of the risk among tasks. The risk level is calculated using the Composite Strain Index from all sub-task risks and Cumulative Strain Index of all tasks in a job. In the detailed table at the lower portion of this report are the main contributors to the job risk level. The goal is to provide enough information to determine safe workloads. If a task is listed multiple times, it means that more than one sub-task added to the overall risk level.

Figure 11 shows that this job has high hand/wrist risk level that should be addressed. The main contributing risks occur in vacuuming and restroom cleaning tasks, so focusing on these two tasks will be more efficient in improving this job.

Figure 11. Report example: Hand/wrist loading

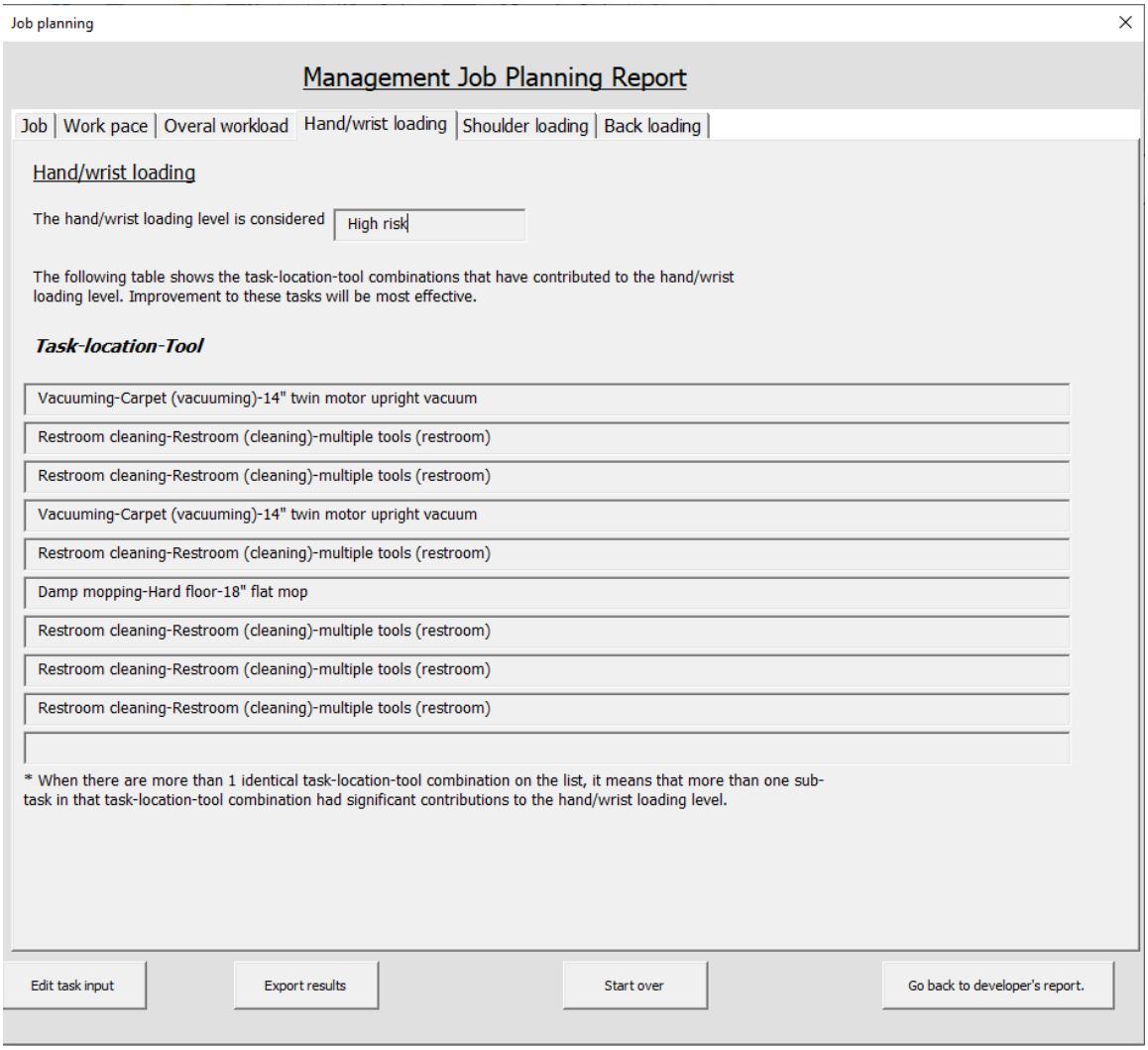


Figure 12 shows the shoulder loading tab that calculates the risk levels to that region. Besides the shoulder exertions, frequency and duty cycle of exertions, task durations are also used in the calculation. The results provide both job level and task level risk for the shoulder.

Our example job results indicate although the job shoulder risk level is low, the task risk level of the restroom cleaning is high. Improving the restroom cleaning tasks to reduce shoulder injury risk will make the job safer and more efficient.

Figure 12. Report example: Shoulder loading

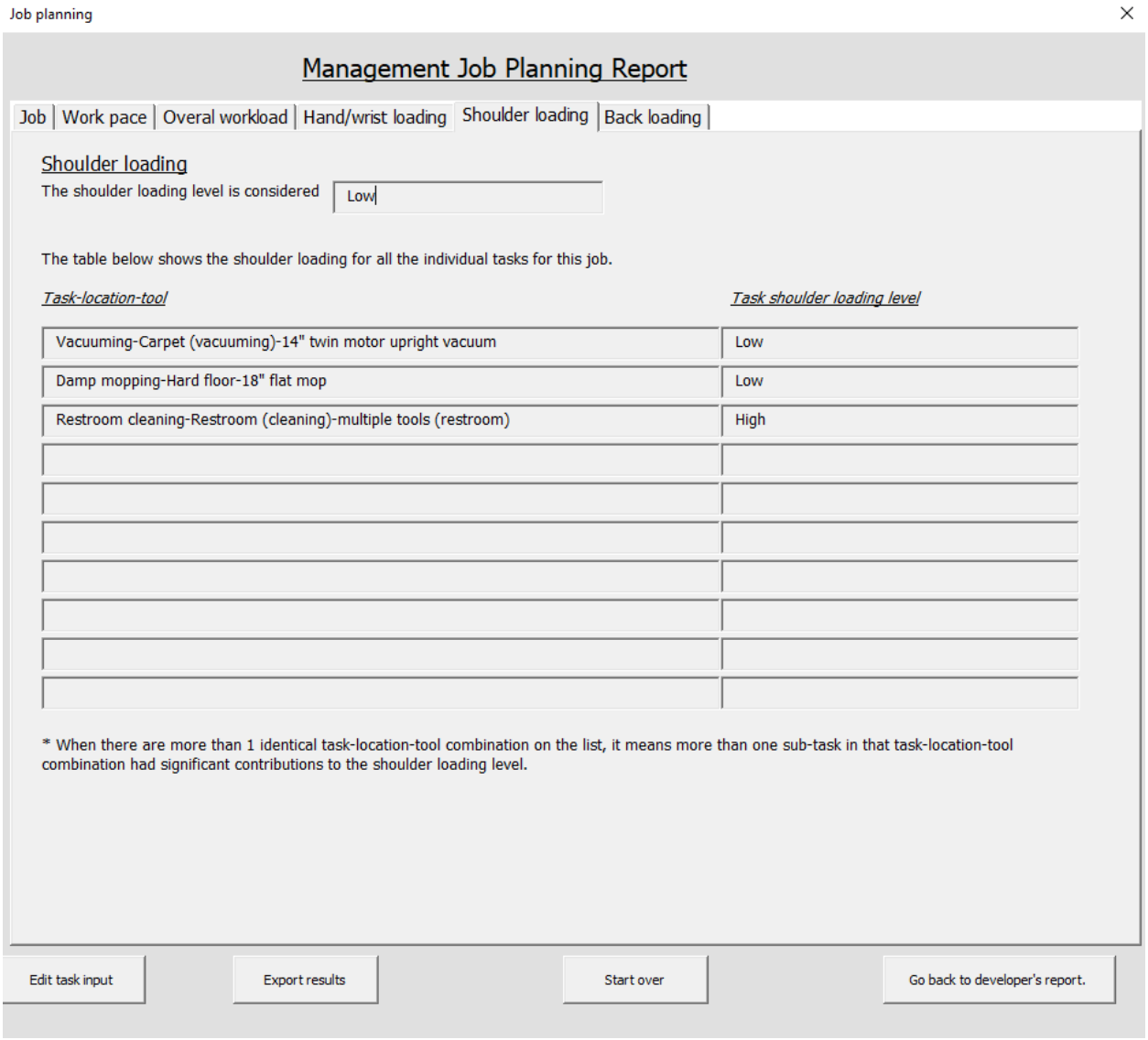
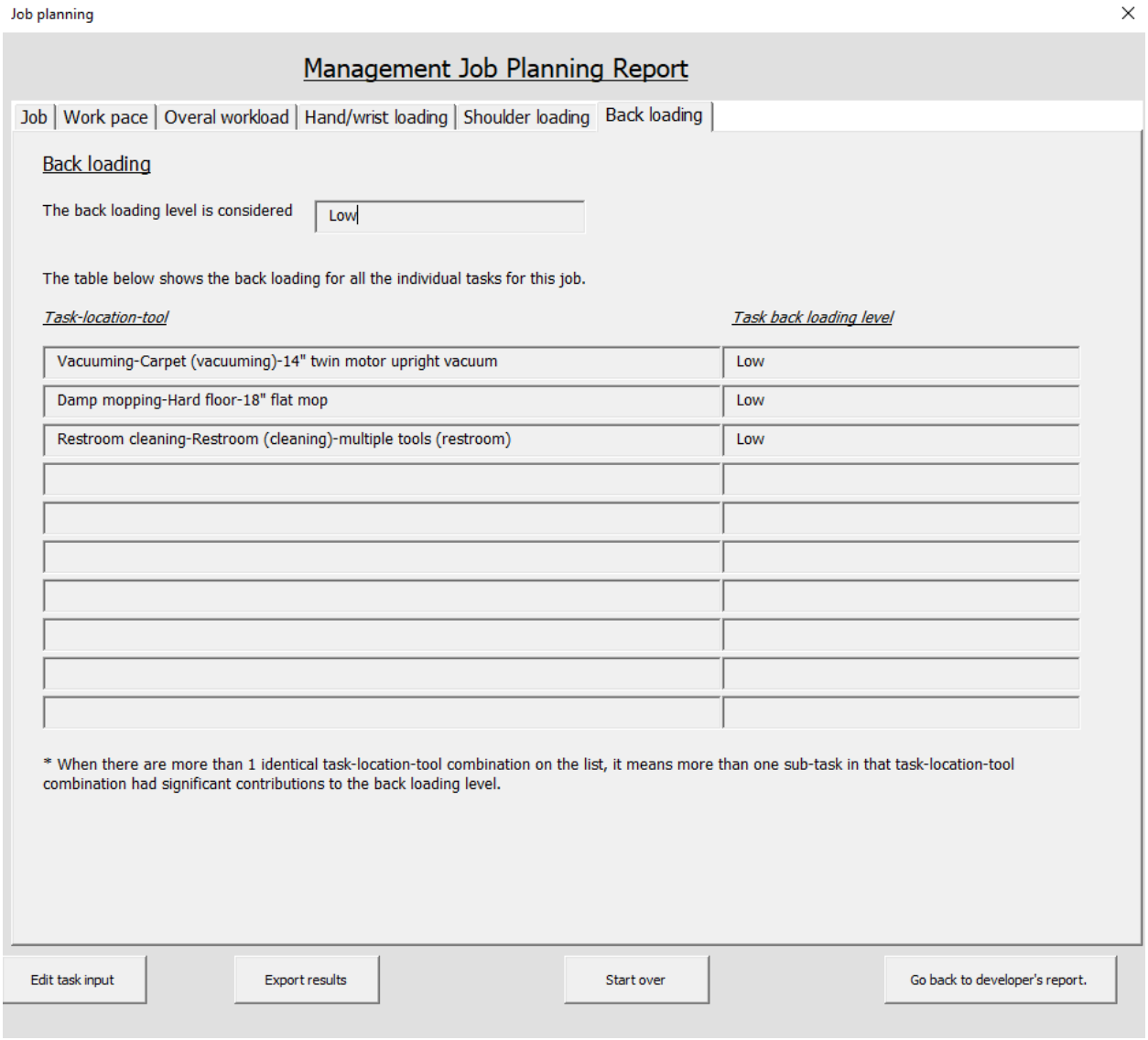


Figure 13 shows results of the low back loading. Similar to the shoulder loading, the RCRA method is used to estimate the risk levels of the low back region as well. Besides the back exertions, frequency and duty cycle of exertions, task durations are also used in the calculation. The results provide the job low back risk level as well as back risk levels of the individual tasks in the job. In our example job (Figure 12) the results indicate low back risk levels at both the job level and individual tasks to be low.

Figure 13. Report example: Back loading

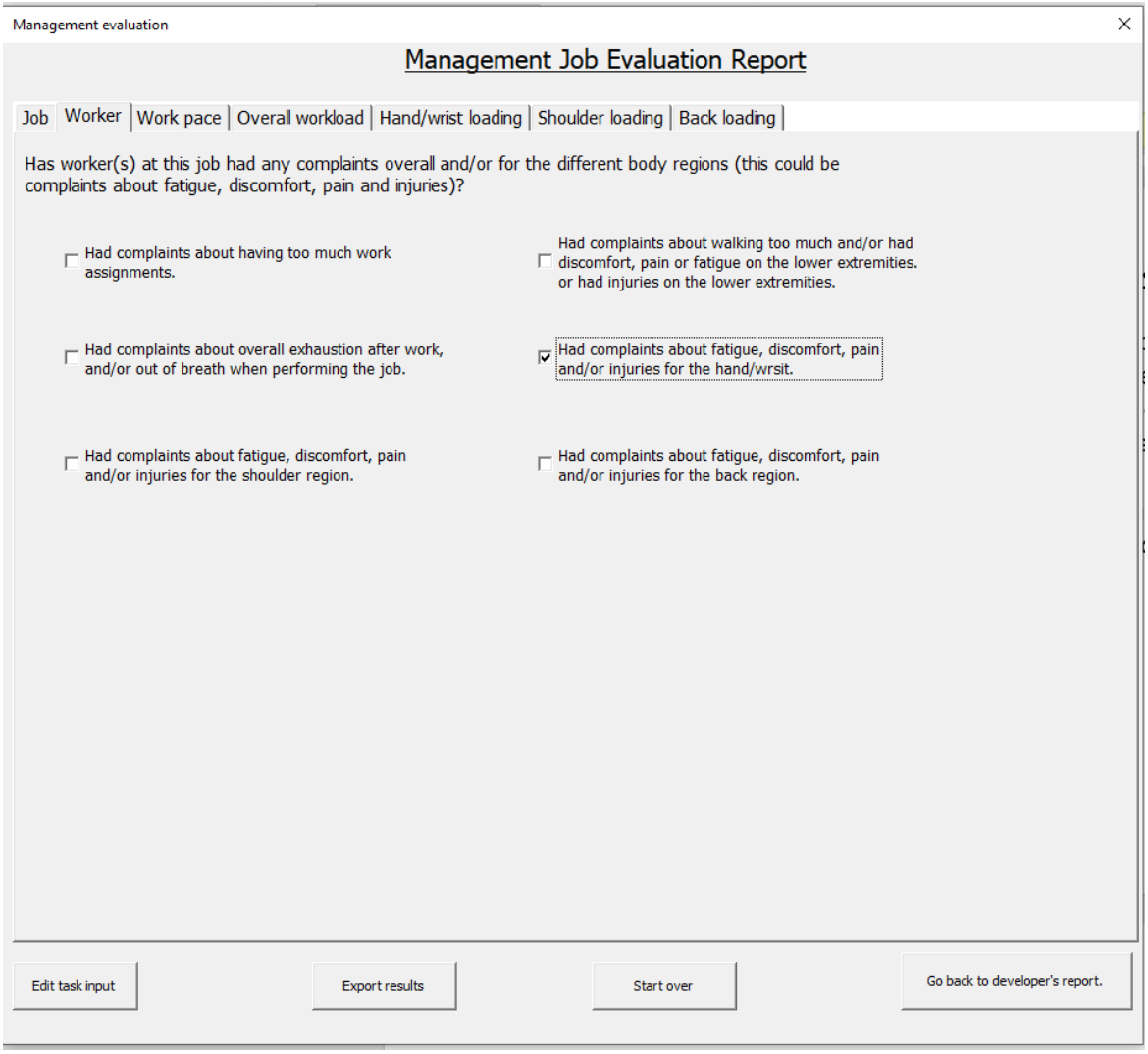


Application 2: Manager/supervisor to evaluate workload of an existing janitorial job

In this application, the jobs are already in place and janitors have been following these job assignments. The managers, supervisors and workers all know the task, locations, and tools that they use. The data entry is exactly the same as in the first application, where tasks, locations, tools and variation parameters are entered together with hours allocated and production specifics (e.g. square feet, number of small trash cans with liners) involved in these tasks. The general structures of the reports are similar to those in application 1. The main addition is a form where the managers/supervisors can enter related historical complaints/issues that workers on the jobs had (Figure 14).

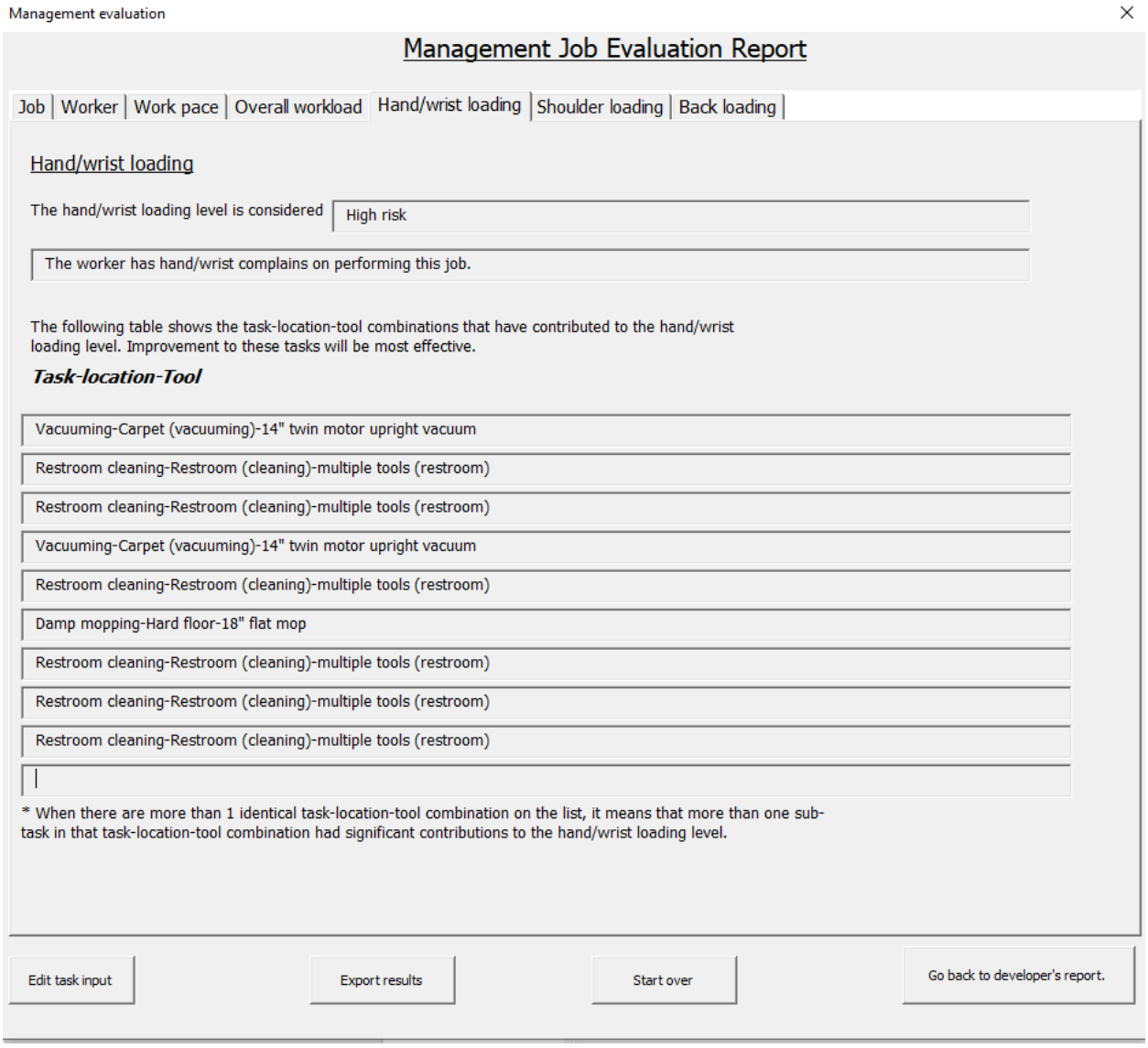
Using the example job data as in the Application 1, hypothetically the workers who had been working on this job voiced concerns to their supervisors that they had experienced fatigue and pain in their hand and wrist region after performing this job. They user of this workload calculator could then check the corresponding box in the form under the tab: Worker (Figure 14).

Figure 14. Form to enter historical data of issues that workers at the job might have experienced.



The different categories of issues reported by the workers at the job are then combined in each of the corresponding workload reports under different tabs. To illustrate this, see Figure 15, the hand/wrist loading job. The report shows that the workload results for the hand/wrist region are exactly the same as seen in the first application. However, the concerns about hand/wrist symptoms reported by the workers is also presented here. This gives the user a comprehensive picture about where high risk exists and may be responsible for worker complaints. Similar structures are built into the reports of work pace, overall workload, shoulder loading, and back loading.

Figure 15. Report example: Hand/wrist location with hand/wrist issues, reported by the worker.



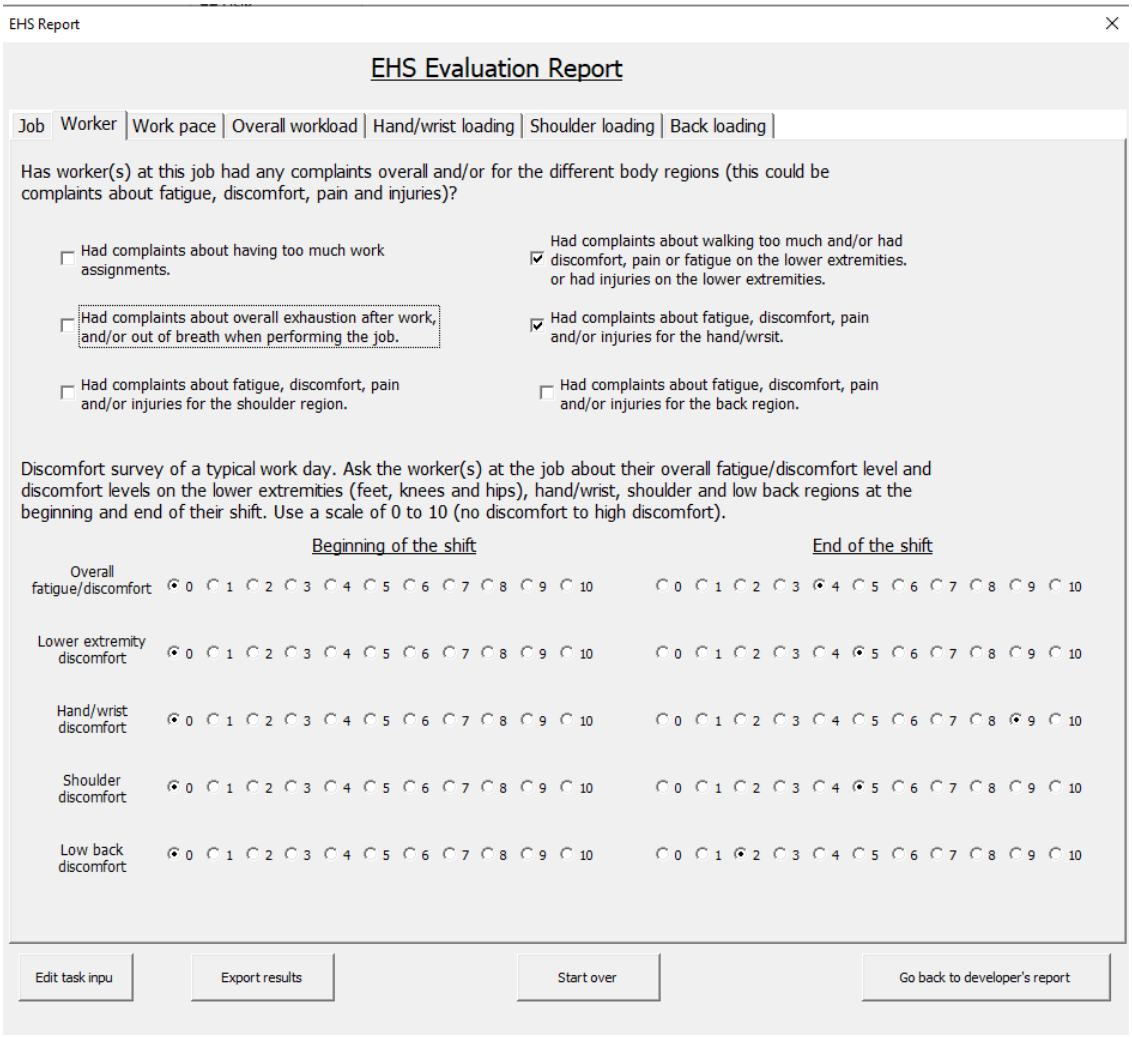
Application 3: Environmental Health and Safety (EHS) practitioner to conduct a risk evaluation for a janitorial job

This application is for EHS practitioners and worker representatives who wish to conduct a workload investigation as a result of a complaint about a job. This group of users generally have more knowledge of occupational risks and ergonomics and are familiar with related terminologies.

Prior to a workload evaluation, the user should gather detailed information about the job to be evaluated. This includes the tasks involved in the job, locations where the tasks are performed, tools to be used to complete these tasks, any special variations for the tasks, hours allocated for each of the tasks, and quantities related to these tasks.

Basic data entry is the same as the other two applications, we provide the same form to log issues. The differences are mainly in the reports. In addition, we also provide a formal discomfort survey tool for the user, as you see in Figure 16. The users complete the discomfort survey at the beginning and end of a job shift to collect data.

Figure 16. A discomfort form in the application of this workload calculator for EHS specialists



The various workload reports, in general, have similar structures as the previous two applications. They are then combined with historical information on worker issues or complaints and the discomfort survey results.

Many of the workload reports contain more detailed information of results with technical terminologies. To illustrate such differences, we present reports using our job example. Figure 17 shows a report on overall workload in this application. Along with the steps, the energy expenditure demands at the job and task levels, the report details worker complaints or issues for this job, and the survey results on the overall workload. It includes discomfort levels

at the beginning and end of the shift for the lower extremity (discomfort level changed from 0 to 5 in this example) and overall discomfort level changes (from 0 to 4 in this example).

It also calculates the ratios of Maximal Allowed Working Time or MAWT and the actual work hours at both the job and task levels. If the ratio is less than 1, it means that on average, a healthy worker has time to recover from muscular exertions. If greater than one, overall fatigue can develop because they don't have enough time between jobs.

Figure 17. Report example: Overall workload report for the EHS specialist application

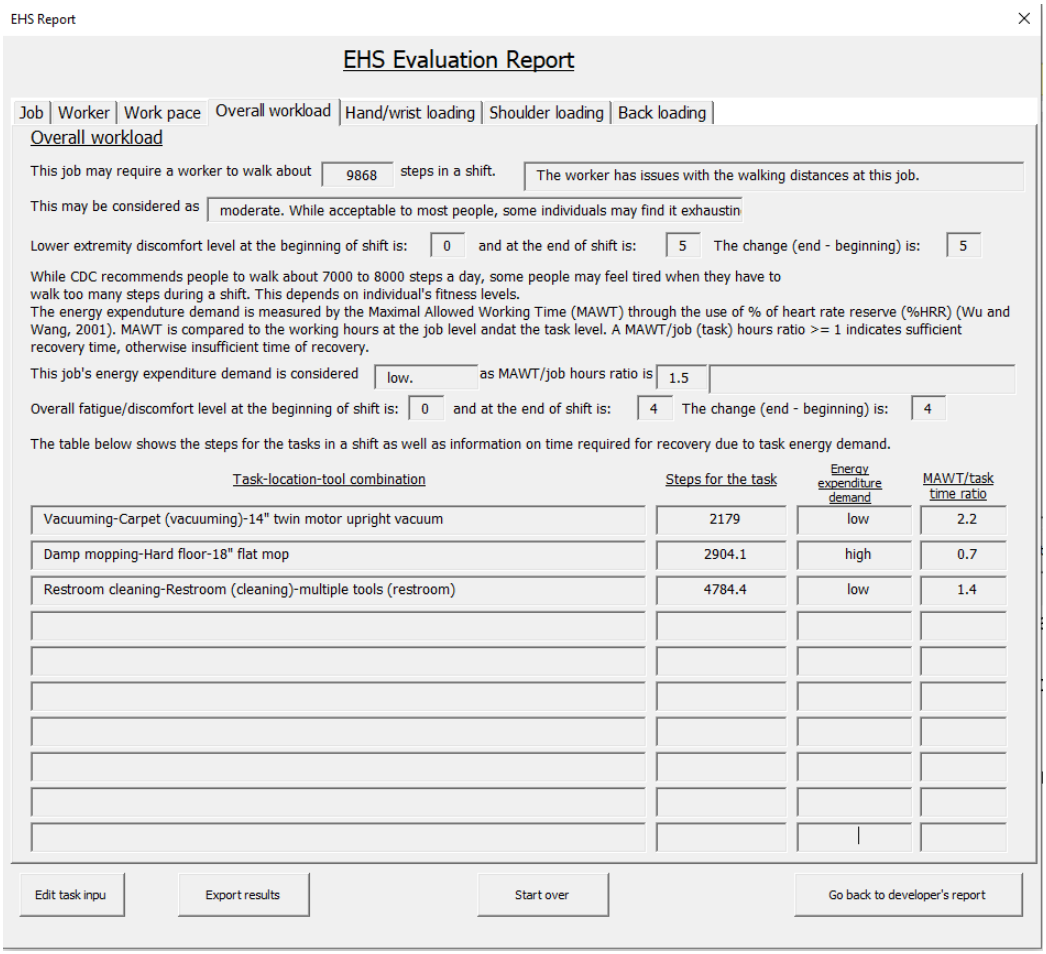


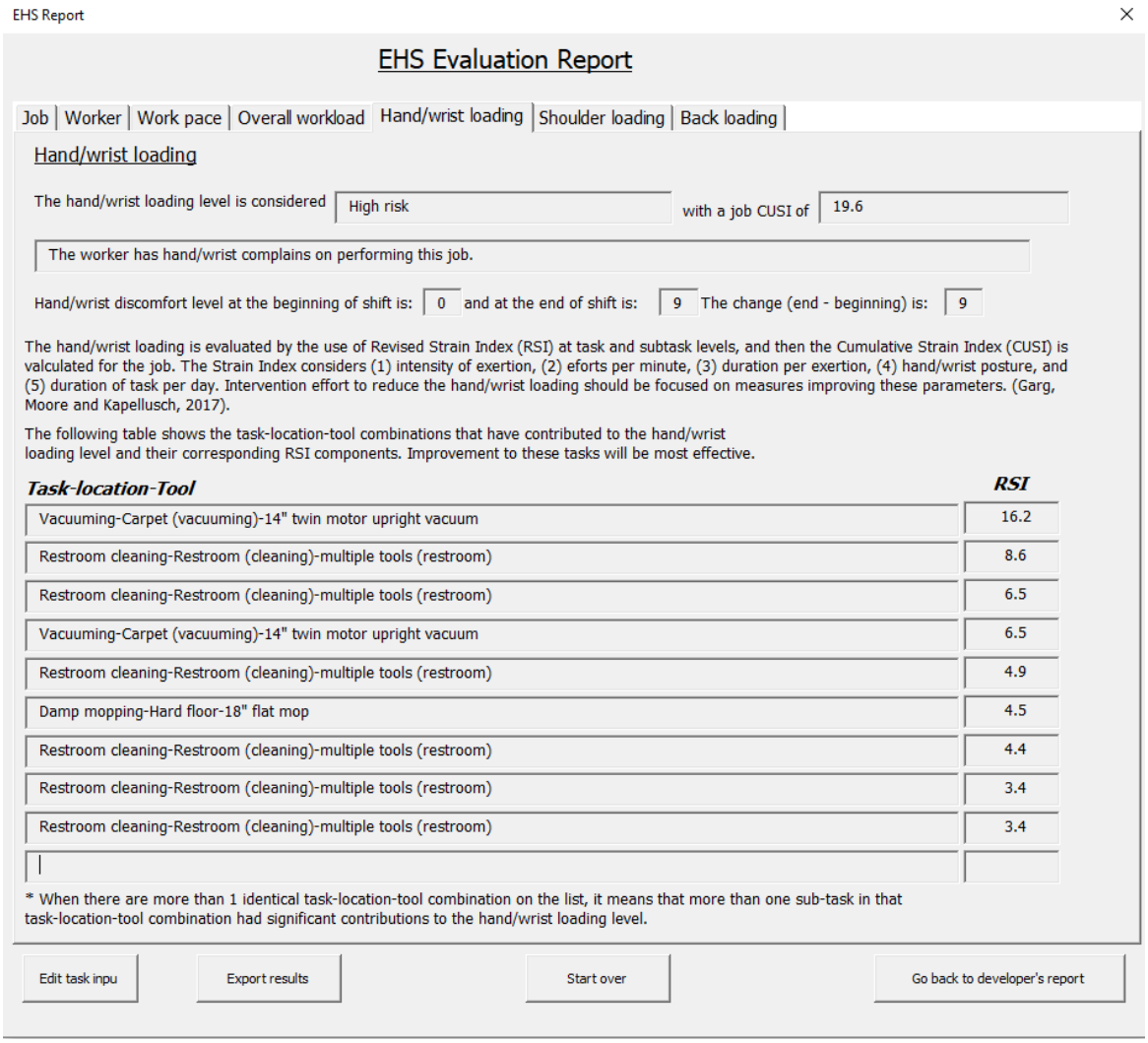
Figure 18 shows a report of hand/wrist loading in this application. In addition to the basic information about risk level at the job, it also provides information on hand/wrist region complaints or issues, and the survey results relative to the hand/wrist loading.

It includes discomfort levels at the beginning and end of the shift for the hand/wrist (discomfort level from 0 to 9 in this example). At the job level, it also includes the Cumulative Strain Index (CUSI) (Garg et al., 2017a) value of this job (19.6) which indicates the risk so that EHS specialists are informed of exactly how high the risk is.

At the task level, the Revised Strain Index (RSI) (Garg et al., 2017b) values are listed for sub-tasks in the different tasks that contribute to the high CUSI. It helps EHS specialists to make decisions on intervention priorities. While the exact sub-task names are not listed, the EHS specialists typically use their knowledge to draw conclusions.

This arrangement is to avoid confusion as sub-task definitions can be arbitrary. The intent is to provide EHS specialists specifics on risk levels of subtasks, so they can make informed decisions on further evaluation to develop efficient interventions.

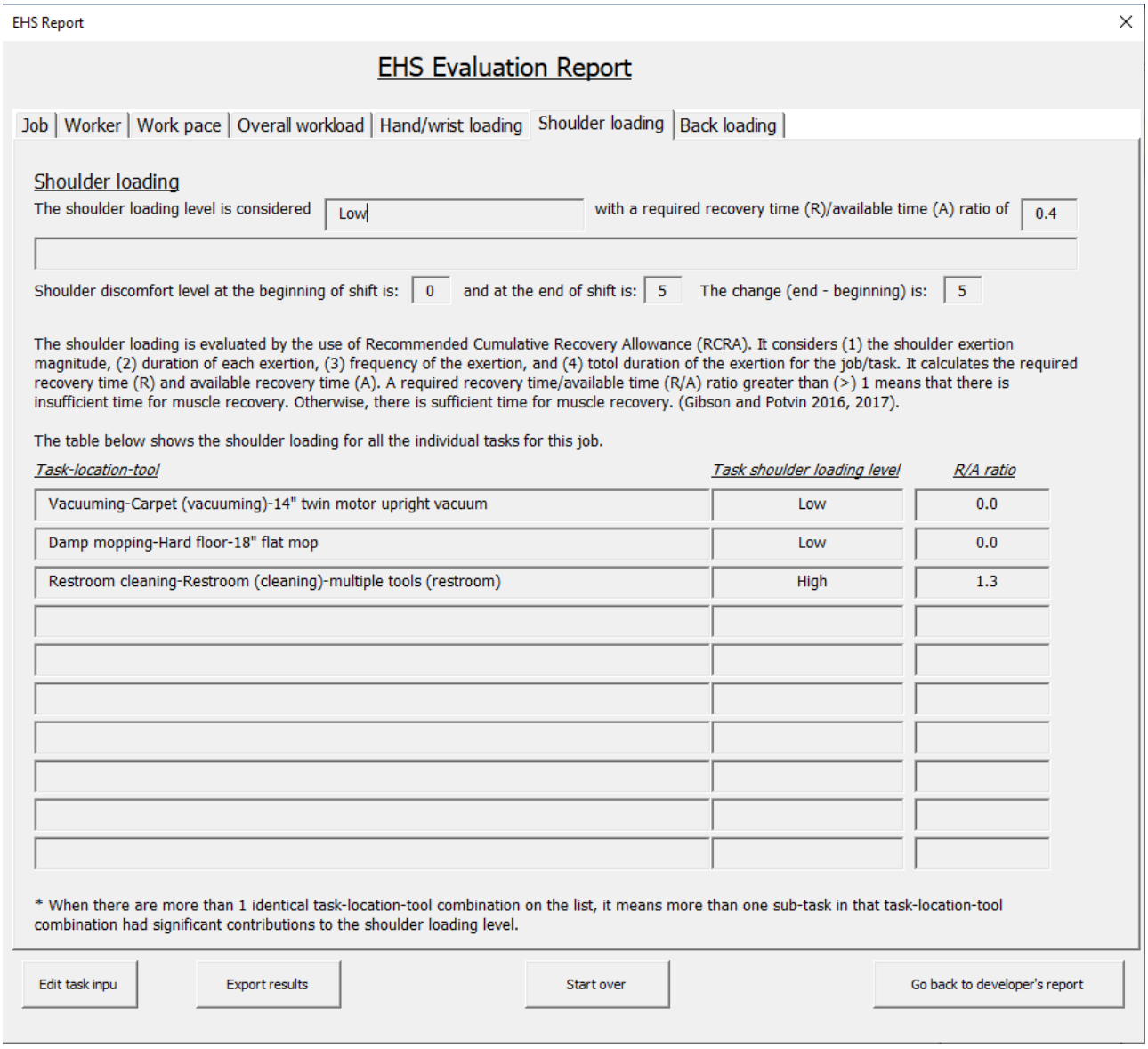
Figure 18. Report example: Hand/wrist loading report for the EHS specialist application



The reports for shoulder and back loading in this application are similar as both use the Recommended Cumulative Recovery Allowance (RCRA) (Gibson & Potvin, 2017). In addition to the basic information on loading level at the job and task, it details worker's complaints or issues on the shoulder and back regions for this job, and survey results relative to shoulder and back loading. In the example shown in Figure 19, the discomfort levels for the shoulder changed from 0 at the beginning shift to 5 at the end of the shift.

The reports for the shoulder and back loading also provide the ratio of required recovery time and available time (R/A ratio). A ratio greater than 1 means that there is insufficient time for the shoulder or low back muscles to recover from muscular exertions (e.g. R/A ratio = 1.3 for the restroom cleaning task). With this information, EHS specialists can focus their intervention effort in the needed aspects.

Figure 19. Report example: Shoulder loading report for the EHS specialist application



Calculator Reference Guide

A reference guide is being developed as an accompaniment. This guide will aid the user as they navigate through the calculator as well as a training document. Below is an outline of the intended contents of the reference guide.

Section 1. Purpose of Calculator

- Intended Use
- Limitations

Section 2. Introduction

- Background
- Calculator development

Section 3. Preparing for Calculator Use

- System Requirements
- Calculator Checklist: a preparatory tool to ensure required information is available

Section 4. Data Input

- Description of job evaluation types
- Description of Input Pages
- Description of buttons (Add another task, Done with task, Generate Report, Start Over)

Section 5. Results Report by Evaluation Type

- Description of the purpose of buttons (Edit task, Export results, Start over)
- Explanation of Job Page
- Explanation of Worker Page
- Explanation of Work Pace page
- Explanation of Overall workload Risk Assessment page
- Explanation of Hand/Wrist Risk Assessment page
- Explanation of Shoulder Risk Assessment page
- Explanation of Back Risk Assessment page

Section 6. Interpreting Report

How to consider all results to determine how to overall risk of job

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