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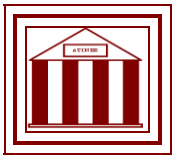

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An Interactive Model of Personal Protective Equipment (PPE) Donning and Doffing Times

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An Interactive Model of Personal Protective Equipment (PPE) Donning and Doffing Times

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Abstract

Personal Protective Equipment (PPE) is specialized clothing or equipment worn to minimize exposure to a variety of occupational hazards. It has been estimated that 20 million workers in the United States wear some form of PPE. How much time it takes for employees to don and doff PPE and whether they should be compensated for this time has been frequently litigated in the last decade. Surprisingly, few studies have been performed to determine empirical donning and doffing times for common PPE used in industry such as earplugs, aprons, safety glasses, gloves, etc. A study was designed to have highly experienced employees (subjects) don and doff PPE that they routinely wear while the researchers conducted a time study of the process. Over 2,000 donning and doffing times for 27 different types of common PPE were included in the time study. Maynard Operation Sequence Technique (M.O.S.T.) was used for validation of the times. A computer model was developed to enable researchers or practitioners to easily determine standard times for donning and doffing using the data obtained from the study. The model allows the user to select individual or combinations of PPE that are worn by workers and calculates the total time required for donning and doffing. The model is statistically sound and robust and demonstrates that Time Study is an effective means of determining don and doff times for PPE.

Keywords: Doffing, Donning, M.O.S.T., Personal protective equipment, Time study.

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Introduction

Various aspects of employment law in United States have historically been, and continue to be, subject to litigation in the court system, including cases eventually being argued before the Supreme Court. One such issue that has seen numerous occurrences of litigation in the past decade relates to the Fair Labor Standards Act (FLSA) of 1938. Essentially, the FLSA contains the workplace rules that most employees and employers are fairly familiar with, addressing such issues as the establishment of the forty (40) hour workweek, paid overtime at a rate of 1.5 X hourly pay (when applicable), the establishment of a National minimum wage, and work permits for children, etc. A related piece of legislation known as the Portal-To-Portal Act (PTPA) of 1947, states that certain employment activities (performed by the employee) may be non-compensable under the FLSA. Relevant to the present research the PTPA states that; 1) Time spent on 'incidental activities' before and/or after the employees' principle activities, and 2) Time spent 'Traveling To/From' the actual place of work where the employees' principle activities are performed; may individually or both be non-compensable, depending on the specifics of each unique circumstance.

A large number of lawsuits have arisen over the past decade relating to the PTPA non-compensable activities, and in larger scope the FLSA in general. Employees in numerous industries such as poultry processing, meat-slaughtering and packing, police and corrections officers, neonatal nurses, commercial bakeries, industrial welders, and clean-room employees, among others have retained plaintiff attorneys to represent themselves (and others) primarily in class action matters. In a general sense, employees feel that the time spent to procure (including waiting), open packaging, remove item(s), dispose of packaging material, don (put on) and adjust the specific item(s), wash and sanitize (if necessary or required), and eventually remove and dispose of the item(s), should all be compensable time as they believe these activities are part of the 'job' and primarily benefit the employer. These employees also assert that this total amount of don/doff & wash/sanitize time in aggregate [pre-shift, (break, post-break), lunch, post-lunch, (break, post-break), post-shift] is substantive enough to merit compensation, more often than not at the overtime rate. Some employers tend to view these tasks in isolation, each taking a very small amount of time, and *De Minimis* in aggregate. With each party believing their perceptions are correct, the court system has seen numerous filings in such matters.

Recent Court Decisions

The most recent major decision relating to donning/doffing matters was delivered by Justice Kennedy for the US Supreme Court in TYSON FOODS, INC., PETITIONER, v. PEG BOUAPHAKEO, ET AL., INDIVIDUALLY AND ON BEHALF OF ALL OTHERS SIMILARLY SITUATED, Supreme Court of the United States [1] argued on November 10, 2015 and decided March 22, 2016. A thorough reading of the decision is needed to understand

particular issues associated with the matter. As it specifically relates to this study, Plaintiff's Expert, Dr. Ken Mericle, conducted a study by videoing 744 observations to analyze how long various donning and doffing activities took. He subsequently averaged the time taken in the observations to produce an estimate of 18 minutes/day for the cut and re-trim departments, and 21.3 minutes/day for the kill department. Tyson desired to reverse the judgment arguing, "the class should not have been certified because the primary method of proving injury assumed each employee spent the same time donning and doffing protective gear, even though differences in the composition of that gear may have meant that, in fact, employees took different amounts of time to don and doff." The opinion further states, "Just as individual managers inherently make discretionary decisions differently, so too do individual employees inherently spend different amounts of time donning and doffing." This defense assertion is not unique to this matter, and is often used to counter scientific studies.

As such, it is prudent to develop and disseminate a tool (model) that can objectively calculate in an unbiased manner how much time should be allocated to donning and doffing common combinations of PPE and sanitation typically found in many of the litigated cases. Using this information, employers can build this amount of time into an allowance for their employees, or choose to compensate them at an overtime rate of pay for all time exceeding forty (40) hours per week. Such a model should be statistically sound and robust enough to withstand external scrutiny.

Methodology

A study was designed to collect the required data for model enhancement and validation, and conducted at a poultry processing facility located in the United States. The fundamental approach in determining the time for employees to don/doff both personal protective equipment (PPE) and sanitization items was to acquire some representative items of PPE and have employees (subjects) demonstrate how it is donned and doffed, while conducting a time study of the process. This group was chosen for a number of reasons: 1) For the most part, these subjects are highly experienced in the donning and doffing procedure as they perform it numerous times per workday. Use of a naïve sample could require some amount of learning (practice) until they demonstrated consistent results; 2) the subjects were readily available and willing to participate and no subject refused to participate or was in any way observed to be uncooperative during the observations; and 3) representative of the plaintiffs in similar actions. None of the employees (subjects) that participated were members of any litigation matter at the time of the study.

Employees (subjects) were recruited to participate in the study. Subjects would leave their normal assignment, wash-up, and report to a facility conference room, as requested. Subjects provided some basic demographic information such as name, job title, and the amount of time employed at the facility. They were asked to remove any PPE or sanitation items they wore to the room, and lay them out in an orderly fashion on a table directly in

front of them. Subjects were provided (out of company stock) with any sanitation items or PPE that they normally wore, but did not bring with them. Though items such as smocks, aprons, and gloves were reused by other participants, personal items such as earplugs, beard-nets & hair-nets, were disposed of after each use for sanitary purposes.

Prior to actually performing any timing of the donning or doffing, the researcher would explain in detail what was about to happen, demonstrate the sequence (usually with earplugs and/or gloves) and start/stop the watch a number of times in order to familiarize the subjects with the sequence and the sound (chirping) that the stopwatch produces. A number of the participants were of Hispanic background and spoke little or none of the English language. In these cases, a translator was provided to the researcher by the facility to ensure these participants were able to communicate with the researcher.

Subjects were asked to don (to put on or dress in) [2] the PPE and sanitation items in their usual order (personal preference) and asked to indicate that they were complete with any individual piece (or pieces such as pairs of gloves) by verbally stating that they were 'done' or indicating such to the researcher with a 'thumbs-up' or other mutually agreed upon signal. Subjects were carefully instructed that though they were being timed, this was not a race, and that they should proceed at their usual (typical) pace. If an error occurred (various reasons) the trial was stopped, the reason explained (acknowledgement obtained), and the trial repeated.

The specific procedure used in the donning trials required that the item be picked up from a standard surface (a table located directly in front of the employee) and returned to the same location at the completion of doffing (to remove or take off, to throw off, to get rid of) [2] the item. By establishing this control, the time to grasp and move the PPE or sanitation item to the location of use is standardized for each participant. Therefore, return times, from the time when the subject indicated completion of the item to the time that they were physically picking up the next item (return arm movement), must be accounted for and added into the model. Likewise, for doffing, this time is the time spent from when the item is laid down on the table, until the participant touches the next item to be removed. This time was added as a function of the number of specific reaches used during any specific donning or doffing combination.

All reaches for these trials were classified "within reach", which is defined as "Actions are confined to an area within the arc of the outstretched arm pivoted about the shoulder. With body assistance--a short bending or turning of the body from the waist—this 'within reach' area is extended somewhat." [3] The use of the A_1 time from the BasicMOST® predetermined time system is an appropriate value to be inserted for this return time. Since the actual time using this approximation is 0.59999999 centi-minutes (cmin), the use of two (2) cmin per return is conservative.

Individual items (or pairs when applicable) were donned, timed, and recorded, prior to proceeding to the next item(s). If the researcher felt a comment was required, it was entered directly on the form. Comments might arise from any number of possibilities, but most were entered to explain why a certain time would appear to be excessively short or long, due

to some external issue associated with the procedure. The snapback method of time study was used [4]. In the snapback method, the researcher resets the clock to zero at each break point of the operation. A break point is an easily identifiable point in time that the researcher chooses as the end of an element (and usually the beginning of the next element).

After sequentially donning (and timing) each individual PPE and sanitation item, the subject was instructed that they would be following the reverse sequence during the doffing phase, and acknowledgement was obtained. Next, the researcher asked the subject to don and doff the same equipment (in exactly the same order) without stopping while being recorded by a digital recorder. Again, the participant was specifically instructed that they should proceed at their 'typical' pace. This recording was primarily for the benefit of the researcher, should it be necessary later to clarify any visible item of use (such as smocks v. apron, one glove v. two, etc.). It also provided the researcher with an uninterrupted video recording against which to compare (validate) the results of the model. At the conclusion of the doffing portion of the taped trial, the subject was instructed that they could begin to don their PPE and sanitation items (required to proceed back to work) while the researcher asked them to verbally answer a few additional questions. Upon completion, they were asked if they had any questions, and thanked for their participation, prior to being released back to their normal work area. The researcher would ensure that all paperwork for the previous participant was in order, and take a moment or so to rearrange the table (stock PPE), dispose of any used PPE or other items, and prepare for the next subject. This process was repeated for the remaining subjects.

Data Entry and Analysis

Data from the individual collection sheets were entered into a Microsoft Excel spreadsheet and subsequently verified for accuracy. For any observed PPE or sanitation item, specific entries were made for participant ID (assigned by the researcher), date, number of this specific item used for don (one or two gloves, etc.), don time, mean don time (don time/number of items), number of this specific item used for doff, doff time, and mean doff time (doff time/number of items). Suspected outliers were annotated for identification. Notes were entered directly into the spreadsheet if found on the data collection form.

After entering data into a spreadsheet, a statistical test was performed to determine if there were any potential outliers. Commonly accepted tests for this purpose are found in a number of statistical texts [5, 6, and 7]. The 1.5*IQR test was chosen for this study. To perform the test, the column of data times was copied into an additional column, rank ordered, and analyzed to determine the first (Q1) and third (Q3) quartiles of the data set. The interquartile range (IQR) is calculated and multiplied by 150%. This resulting product is then subtracted from Q1 and added to Q3 to obtain the range of inclusive data. Data that exceeds these values (high or low) are classified as suspected outliers and treated accordingly in subsequent data

analysis. Of the 936 times measured during the study, 22 data points, or 2.4% were deemed as outliers. Twenty (20) of the twenty-two (22) data points have researcher comments explaining the excessive times.

Results

A Microsoft Excel spreadsheet model was refined for this study. The model developed in previous studies utilizes a database containing over 2000 individual donning/doffing times associated with pieces of PPE/sanitation equipment items routinely used in poultry processing applications. Figure 1 summarizes the standard data obtained from the study. The "Raw" column in Figure 1 represents the average time obtained from the time study, while the "Filtered" column represents the average time after outliers were removed. Figures 2 through 14 illustrate the various types of PPE studied. Figures 15 through 28 show the output of Excel's statistical tests for the data from each type of PPE studied. This output is obtained when the "Analysis ToolPak" add-in is used in Excel with "Descriptive Statistics."

Figure 1. *Summary of Standard Data in Centiminutes*

		Raw		Filtered	
Item	**n**	**Don**	**Doff**	**Don**	**Doff**
Apron-Blue	145	25.5	13.6	24.2	12.1
Apron-Disposable	55	54.4	7.9	52.9	7.4
Arm Guard	81	5.8	4.0	4.9	3.9
Boots-High	33	12.4	7.8	11.6	6.9
Boots-Mid	76	28.8	18.1	25.8	15.8
Boots-Yellow Low	61	24.1	12.2	20.8	11.0
Bump Cap	35	6.4	4.2	6.1	4.1
Ear Muffs	28	5.1	3.6	4.4	3.2
Ear Plugs-Foam	64	17.3	7.6	16.6	5.9
Ear Plugs-Non Foam	123	14.9	7.5	13.7	6.1
Eyeglasses-Safety	34	8.9	4.9	8.3	4.7
Glove-Blue	80	13.3	5.6	12.7	4.9
Glove-Cloth	177	10.2	5.3	8.9	4.9
Glove-Kevlar	56	9.2	5.9	8.5	5.8
Glove-Metal Mesh	16	21.3	6.5	21.3	6.5
Glove-Rubber	194	11.1	5.7	10.0	5.3
Mask-Dust	4	13.5	5.3	8.4	5.3
Net-Beard	101	12.8	5.6	12.8	4.9
Net-Hair	202	15.1	6.0	14.6	5.6
Rain Suit-Jacket	30	43.4	16.2	42.1	15.2
Rain Suit-Pants	30	56.2	36.7	56.2	29.4
Sleeves	74	17.8	5.5	15.0	4.8
Sleeves-Disposable	70	13.0	4.4	12.3	4.1
Smock-Cloth	160	35.8	14.6	34.2	13.8
Smock-Cloth Button	81	38.4	12.6	37.5	12.3
Smock-Paper	11	44.7	16.5	44.7	16.6
Smock-Paper Tie	6	36.1	17.2	36.1	17.2

Figure 2. *Beard-Net*

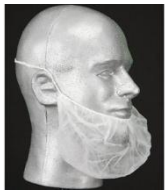

Figure 3. Hair-Net

Figure 4. *Bump Cap*

Figure 5. *Rubber Gloves*

Figure 6. *Cloth Gloves*

Figure 7. *Plastic Sleeves*

Figure 8. *Safety Glasses*

Figure 9. *Metal Mesh Gloves*

Figure 10. *Cloth Smock*

Figure 11. *Apron (Tie-up)*

Figure 12. *Ear Plugs*

Figure 13. *Rain Suit*

Figure 14. *"Whizard" Glove (Anti-cut)*

Figure 15. *Apron-Blue and Apron-Disposable Statistical Analysis*

	Apron-Blue				Apron-Disposable			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	25.45793	13.58276	24.21898	12.11278	54.36182	7.903636	52.92075	7.382692
Standard Error	0.621699	0.541844	0.474528	0.274085	1.589815	0.433652	1.253987	0.334873
Median	23.8	11.9	23.5	11.8	51.3	7.3	51.3	7.15
Mode	30.2	11	30.2	11	44.6	6.7	44.6	6.7
Standard Deviation	7.486244	6.524668	5.554205	3.160898	11.79038	3.216046	9.129166	2.414801
Sample Variance	56.04384	42.5713	30.8492	9.991275	139.0131	10.34295	83.34168	5.831263
Kurtosis	1.822256	15.19837	-0.2308	0.135505	3.610404	1.61407	-0.46839	-0.98548
Skewness	1.308624	3.318191	0.581769	0.649416	1.556556	1.098496	0.617753	0.145951
Range	36.2	47.7	24.5	15	62.4	14.6	33.7	8.8
Minimum	14.8	6.2	14.8	6.2	38.7	3.2	38.7	3.2
Maximum	51	53.9	39.3	21.2	101.1	17.8	72.4	12
Sum	3691.4	1969.5	3318	1611	2989.9	434.7	2804.8	383.9
Count	145	145	137	133	55	55	53	52
Confidence Level (95.0%)	1.228834	1.070996	0.938408	0.542166	3.187387	0.869419	2.51631	0.672285

Figure 16. *Arm Guard and Boots-High Statistical Analysis*

	Arm Guard				Boots-High			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	5.790123	4.039506	4.923288	3.912821	12.4303	7.8	11.59688	6.866667
Standard Error	0.398355	0.118474	0.184508	0.097391	1.157596	0.657777	0.828895	0.432085
Median	4.9	3.9	4.8	3.8	10.9	6.7	10.9	6.55
Mode	3.2	3.8	3.2	3.8	9	6.5	9	3.9
Standard Deviation	3.585199	1.066264	1.576434	0.860136	6.649882	3.778641	4.688936	2.366626
Sample Variance	12.85365	1.13692	2.485145	0.739833	44.22093	14.27813	21.98612	5.60092
Kurtosis	20.50869	1.842547	0.802876	-0.26057	7.093086	2.089756	-0.28479	-0.20481
Skewness	3.821681	1.055287	0.869745	0.26372	2.186166	1.362967	0.693686	0.170273
Range	26.3	5.4	7.2	4	34.5	16.5	17	10.3
Minimum	2.2	2.2	2.2	2.2	4.6	2	4.6	2
Maximum	28.5	7.6	9.4	6.2	39.1	18.5	21.6	12.3
Sum	469	327.2	359.4	305.2	410.2	257.4	371.1	206
Count	81	81	73	78	33	33	32	30
Confidence Level (95.0%)	0.792753	0.23577	0.367809	0.193931	2.357946	1.339848	1.690542	0.883713

Figure 17. *Boots-Mid and Boots-Yellow Low Statistical Analysis*

	Boots-Mid				Boots-Yellow Low			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	28.83816	18.13289	25.81944	15.8274	24.11148	12.22459	20.79464	10.95263
Standard Error	2.175792	1.78267	1.667268	1.18204	1.861837	0.856782	1.284987	0.624209
Median	24	14.75	23.2	14	20.9	10.4	19.85	10.1
Mode	11.3	5.3	11.3	5.3	16	8.7	15.4	8.7
Standard Deviation	18.96811	15.54096	14.14724	10.09936	14.54141	6.691678	9.615961	4.712677
Sample Variance	359.7893	241.5214	200.1444	101.997	211.4527	44.77855	92.4667	22.20932
Kurtosis	2.259438	9.281239	0.30681	-0.17638	1.551691	2.076452	-0.12334	-0.76561
Skewness	1.489853	2.543607	0.920828	0.816569	1.367498	1.292292	0.656708	0.266902
Range	92.8	93.5	60	38.1	61.9	32	38.8	17.8
Minimum	4	3.1	4	3.1	4.8	2.4	4.8	2.4
Maximum	96.8	96.6	64	41.2	66.7	34.4	43.6	20.2
Sum	2191.7	1378.1	1859	1155.4	1470.8	745.7	1164.5	624.3
Count	76	76	72	73	61	61	56	57
Confidence Level (95.0%)	4.3344	3.551261	3.324438	2.356354	3.724229	1.713818	2.575171	1.250441

Figure 18. *Bump Cap and Ear Muffs Statistical Analysis*

	Bump Cap				Ear Muffs			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	6.351429	4.225714	6.091176	4.070588	5.060714	3.557143	4.448	3.224
Standard Error	0.449451	0.255473	0.377376	0.209044	0.424711	0.254766	0.284846	0.194789
Median	5.9	4.1	5.8	4.05	4.3	3.15	4.1	3
Mode	6.3	5.2	2.9	4.1	4.1	3	2.7	3
Standard Deviation	2.658988	1.511396	2.200464	1.218924	2.247359	1.348093	1.424231	0.973944
Sample Variance	7.070218	2.284319	4.842041	1.485775	5.050622	1.817354	2.028433	0.948567
Kurtosis	2.298918	3.054996	-0.38329	-0.43127	0.901178	0.332463	-0.07615	0.698732
Skewness	1.132672	1.295753	0.34798	0.349075	1.174807	0.935285	0.452638	0.663208
Range	12.8	7.3	8.8	4.6	8.6	5.2	6	3.9
Minimum	2.4	2.2	2.4	2.2	1.8	1.6	1.8	1.6
Maximum	15.2	9.5	11.2	6.8	10.4	6.8	7.8	5.5
Sum	222.3	147.9	207.1	138.4	141.7	99.6	111.2	80.6
Count	35	35	34	34	28	28	25	25
Confidence Level (95.0%)	0.913394	0.519183	0.767778	0.425303	0.871435	0.522736	0.587894	0.402024

Figure 19. *Ear Plugs-Foam and Ear Plugs-Non Foam Statistical Analysis*

	Ear Plugs-Foam				Ear Plugs-Non Foam			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	17.31719	7.60625	16.63548	5.868966	14.87967	7.543089	13.70085	6.083478
Standard Error	0.951785	0.777061	0.848634	0.284413	0.791369	0.591748	0.55912	0.245903
Median	16.9	6.1	16.5	5.4	12.1	5.4	11.85	5.3
Mode	10.6	6.3	10.6	6.3	10.2	4.1	9.4	4.1
Standard Deviation	7.614284	6.216488	6.682154	2.166022	8.776711	6.5628	6.073601	2.637015
Sample Variance	57.97732	38.64472	44.65118	4.691652	77.03065	43.07034	36.88863	6.953847
Kurtosis	0.696748	8.581598	-0.06805	0.116678	13.26736	16.70133	0.344871	0.755473
Skewness	0.844992	2.862517	0.513627	0.582392	2.783662	3.655712	0.992815	1.151985
Range	36.5	32.4	31.4	9	66.8	47.3	26.4	11.6
Minimum	3.8	2	3.8	2	4.3	2	4.3	2
Maximum	40.3	34.4	35.2	11	71.1	49.3	30.7	13.6
Sum	1108.3	486.8	1031.4	340.4	1830.2	927.8	1616.7	699.6
Count	64	64	62	58	123	123	118	115
Confidence Level (95.0%)	1.901992	1.552832	1.696949	0.569526	1.566595	1.171424	1.107308	0.487132

Figure 20. *Eyeglasses, Safety and Glove-Blue Statistical Analysis*

	Eyeglasses, Safety				Glove-Blue			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	8.858824	4.908824	8.303125	4.721212	13.3475	5.565	12.72368	4.937333
Standard Error	0.583723	0.294736	0.464755	0.234309	0.474908	0.380727	0.37612	0.26439
Median	8.2	4.45	7.5	4.4	12.9	4.45	12.7	4.3
Mode	5.9	4.1	5.9	4.1	11.4	4.2	11.4	4.2
Standard Deviation	3.403663	1.718591	2.629054	1.346003	4.247709	3.405323	3.278938	2.289682
Sample Variance	11.58492	2.953556	6.911925	1.811723	18.04303	11.59623	10.75143	5.242641
Kurtosis	1.086702	3.897038	0.309539	-0.05358	2.222123	4.918099	-0.30321	0.250333
Skewness	1.282439	1.625866	0.996621	0.707443	1.109468	1.946406	0.159258	0.949529
Range	12.7	8.6	9.9	5.4	23.2	18.9	14.7	9.9
Minimum	5.2	2.5	5.2	2.5	6	1.4	6	1.4
Maximum	17.9	11.1	15.1	7.9	29.2	20.3	20.7	11.3
Sum	301.2	166.9	265.7	155.8	1067.8	445.2	967	370.3
Count	34	34	32	33	80	80	76	75
Confidence Level (95.0%)	1.187594	0.599645	0.947875	0.477272	0.945281	0.757818	0.749269	0.526808

Figure 21. *Glove-Cloth and Glove-Kevlar Statistical Analysis*

	Glove-Cloth				Glove-Kevlar			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	10.22542	5.253672	8.925625	4.885294	9.176786	5.921429	8.492453	5.805455
Standard Error	0.375552	0.214619	0.215592	0.167658	0.507432	0.346623	0.339051	0.33264
Median	9.1	4.4	8.55	4.35	8.55	5.3	8.2	5.2
Mode	10.5	3.6	10.5	3.6	7.3	3.8	7.3	3.8
Standard Deviation	4.996394	2.855318	2.727042	2.185987	3.797271	2.593889	2.468326	2.466923
Sample Variance	24.96395	8.152842	7.436761	4.77854	14.41927	6.72826	6.092634	6.08571
Kurtosis	5.742775	3.798669	-0.47571	-0.12679	4.591039	-0.02282	-0.5241	-0.04149
Skewness	2.061375	1.661217	0.403841	0.800374	1.869892	0.762882	0.447963	0.718139
Range	30.3	16.7	10.9	9	19.3	11.6	9.6	10.8
Minimum	4.1	1.7	4.1	1.7	4.2	0.7	4.2	0.7
Maximum	34.4	18.4	15	10.7	23.5	12.3	13.8	11.5
Sum	1809.9	929.9	1428.1	830.5	513.9	331.6	450.1	319.3
Count	177	177	160	170	56	56	53	55
Confidence Level (95.0%)	0.741165	0.423558	0.425793	0.330973	1.016916	0.694648	0.680355	0.666903

Figure 22. *Glove-Metal Mesh and Glove-Rubber Statistical Analysis*

	Glove-Metal Mesh				Glove-Rubber			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	21.25625	6.51875	21.25625	6.51875	11.14278	5.690206	10.00276	5.320745
Standard Error	3.353592	0.897832	3.353592	0.897832	0.412671	0.229845	0.234203	0.176724
Median	20.55	5.75	20.55	5.75	9.85	5.1	9.6	4.95
Mode	#N/A	#N/A	#N/A	#N/A	9.8	6	7.5	6
Standard Deviation	13.41437	3.591326	13.41437	3.591326	5.747843	3.201369	3.15088	2.423116
Sample Variance	179.9453	12.89763	179.9453	12.89763	33.03769	10.24876	9.928048	5.871492
Kurtosis	-0.18806	-0.03321	-0.18806	-0.03321	14.96447	5.689808	-0.15979	-0.21561
Skewness	0.598101	0.754034	0.598101	0.754034	3.134124	1.852476	0.544362	0.626889
Range	47.1	12.5	47.1	12.5	43.7	21.6	14.5	10.6
Minimum	3.9	1.9	3.9	1.9	3.8	1.4	3.8	1.4
Maximum	51	14.4	51	14.4	47.5	23	18.3	12
Sum	340.1	104.3	340.1	104.3	2161.7	1103.9	1810.5	1000.3
Count	16	16	16	16	194	194	181	188
Confidence Level (95.0%)	7.148013	1.913683	7.148013	1.913683	0.813924	0.45333	0.462137	0.348629

Figure 23. *Mask-Dust and Net-Beard Statistical Analysis*

	Mask-Dust				Net-Beard			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	13.45	5.3	8.366667	5.3	12.78218	5.620792	12.78218	4.935417
Standard Error	5.102042	1.387444	0.617342	1.387444	0.448269	0.353075	0.448269	0.159336
Median	8.95	5.2	8.6	5.2	12.8	4.7	12.8	4.7
Mode	#N/A	#N/A	#N/A	#N/A	10.7	4.9	10.7	4.9
Standard Deviation	10.20408	2.774887	1.069268	2.774887	4.50505	3.548361	4.50505	1.561172
Sample Variance	104.1233	7.7	1.143333	7.7	20.29548	12.59086	20.29548	2.437259
Kurtosis	3.859295	-0.04144	#DIV/0!	-0.04144	-0.22018	15.33879	-0.22018	0.270122
Skewness	1.95572	0.191888	-0.93522	0.191888	0.435174	3.592751	0.435174	0.903414
Range	21.5	6.6	2.1	6.6	20.2	23.7	20.2	7
Minimum	7.2	2.1	7.2	2.1	4.8	2.4	4.8	2.4
Maximum	28.7	8.7	9.3	8.7	25	26.1	25	9.4
Sum	53.8	21.2	25.1	21.2	1291	567.7	1291	473.8
Count	4	4	3	4	101	101	101	96
Confidence Level (95.0%)	16.23697	4.415465	2.656208	4.415465	0.889353	0.700491	0.889353	0.316323

Figure 24. *Net-Hair and Rain Suit-Jacket Statistical Analysis*

	Net-Hair				Rain Suit-Jacket			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	15.0599	6.002475	14.62374	5.551832	43.38	16.15	42.11724	15.20357
Standard Error	0.485352	0.202841	0.442491	0.159461	2.270862	1.047732	1.953638	0.869539
Median	13.4	5.2	13.25	5.1	43.35	14.55	43.3	14.45
Mode	12.3	3.5	12.3	3.5	#N/A	#N/A	#N/A	#N/A
Standard Deviation	6.898152	2.882913	6.226396	2.203797	12.43802	5.738662	10.52066	4.601166
Sample Variance	47.5845	8.311188	38.76801	4.85672	154.7044	32.93224	110.6843	21.17073
Kurtosis	1.085945	2.034242	0.236561	-0.04989	1.232009	0.641085	-0.51544	0.338439
Skewness	1.101144	1.387512	0.850224	0.841859	0.848282	0.980744	0.226339	0.705938
Range	36.7	16.2	29.5	9.5	55.4	24.2	41.9	18.9
Minimum	4	2.1	4	2.1	24.6	7.1	24.6	7.1
Maximum	40.7	18.3	33.5	11.6	80	31.3	66.5	26
Sum	3042.1	1212.5	2895.5	1060.4	1301.4	484.5	1221.4	425.7
Count	202	202	198	191	30	30	29	28
Confidence Level (95.0%)	0.957035	0.399969	0.872627	0.314542	4.644434	2.142852	4.001846	1.784146

Figure 25. *Rain Suit-Pants and Sleeves Statistical Analysis*

	Rain Suit-Pants				Sleeves			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	56.17333	36.71667	56.17333	29.39643	17.78649	5.490541	15.01642	4.774648
Standard Error	3.437434	6.120593	3.437434	2.603795	1.272372	0.513293	0.656318	0.216156
Median	50.7	24.4	50.7	23.9	14.4	4.45	13.8	4.4
Mode	50.7	16.1	50.7	16.1	13.5	3.1	13.5	3.1
Standard Deviation	18.8276	33.52387	18.8276	13.77799	10.94536	4.415513	5.372195	1.821359
Sample Variance	354.4786	1123.85	354.4786	189.8329	119.8009	19.49676	28.86048	3.317348
Kurtosis	-0.03957	15.07655	-0.03957	0.574312	9.343411	32.11268	0.258917	-0.33152
Skewness	0.624595	3.552665	0.624595	1.047564	2.693756	5.027557	0.813938	0.582667
Range	76.7	177.4	76.7	55.9	63.8	34.5	22.8	8.1
Minimum	25.4	11.6	25.4	11.6	6.4	1.5	6.4	1.5
Maximum	102.1	189	102.1	67.5	70.2	36	29.2	9.6
Sum	1685.2	1101.5	1685.2	823.1	1316.2	406.3	1006.1	339
Count	30	30	30	28	74	74	67	71
Confidence Level (95.0%)	7.030342	12.51802	7.030342	5.342546	2.535834	1.022991	1.310381	0.431109

Figure 26. *Sleeves-Disposable and Smock-Cloth Statistical Analysis*

	Sleeves-Disposable				Smock-Cloth			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	13.02714	4.38	12.30909	4.120588	35.81813	14.59688	34.24013	13.775
Standard Error	0.578045	0.25728	0.484832	0.177703	0.805332	0.412551	0.591405	0.305824
Median	12.3	4.1	11.35	4.05	34.15	13.35	33.9	13.2
Mode	10.7	4.1	10.7	4.1	39.6	11.9	39.6	11.9
Standard Deviation	4.836274	2.152558	3.93879	1.465377	10.18673	5.218405	7.291329	3.770454
Sample Variance	23.38954	4.633507	15.51407	2.147331	103.7694	27.23175	53.16348	14.21632
Kurtosis	0.557965	11.79901	0.025824	-0.42717	5.345457	4.057963	-0.08336	0.406902
Skewness	0.987632	2.632579	0.69614	0.42016	1.723652	1.717957	0.329527	0.807713
Range	22.3	14.4	17.4	5.9	70.3	33.2	38.7	18.2
Minimum	4.7	1.6	4.7	1.6	15.7	6.4	15.7	6.4
Maximum	27	16	22.1	7.5	86	39.6	54.4	24.6
Sum	911.9	306.6	812.4	280.2	5730.9	2335.5	5204.5	2093.8
Count	70	70	66	68	160	160	152	152
Confidence Level (95.0%)	1.153169	0.513259	0.968276	0.354697	1.590527	0.814787	1.168497	0.604247

Figure 27. *Smock-Cloth Button and Smock-Paper Statistical Analysis*

	Smock-Cloth Button				Smock-Paper			
	Raw		Filtered		Raw		Filtered	
	Don	Doff	Don	Doff	Don	Doff	Don	Doff
Mean	38.43333	12.57654	37.50886	12.31772	44.73636	16.59091	44.73636	16.59091
Standard Error	1.20543	0.449826	1.034167	0.421889	4.120862	1.775718	4.120862	1.775718
Median	35.3	12.6	35.3	12.5	42.2	14.8	42.2	14.8
Mode	32.9	13.1	32.8	13.1	#N/A	#N/A	#N/A	#N/A
Standard Deviation	10.84887	4.048434	9.191875	3.749829	13.66735	5.88939	13.66735	5.88939
Sample Variance	117.698	16.38982	84.49056	14.06122	186.7965	34.68491	186.7965	34.68491
Kurtosis	2.468915	-0.18502	-0.07874	-0.5219	-0.53873	0.712062	-0.53873	0.712062
Skewness	1.297753	0.433759	0.681931	0.239256	0.552344	0.906939	0.552344	0.906939
Range	61.3	17.6	39.2	16.1	42.2	20.6	42.2	20.6
Minimum	20.4	5.4	20.4	5.4	25.1	8.6	25.1	8.6
Maximum	81.7	23	59.6	21.5	67.3	29.2	67.3	29.2
Sum	3113.1	1018.7	2963.2	973.1	492.1	182.5	492.1	182.5
Count	81	81	79	79	11	11	11	11
Confidence Level (95.0%)	2.398882	0.895182	2.058868	0.839916	9.181853	3.956546	9.181853	3.956546

Figure 28. *Smock-Paper Tie Statistical Analysis*

	Smock-Paper Tie			
	Raw		Filtered	
	Don	Doff	Don	Doff
Mean	36.06667	17.2	36.06667	17.2
Standard Error	3.596171	1.298204	3.596171	1.298204
Median	37.15	17.3	37.15	17.3
Mode	#N/A	18.9	#N/A	18.9
Standard Deviation	8.808783	3.179937	8.808783	3.179937
Sample Variance	77.59467	10.112	77.59467	10.112
Kurtosis	0.056786	-1.40179	0.056786	-1.40179
Skewness	-0.45911	0.305472	-0.45911	0.305472
Range	25.1	8.2	25.1	8.2
Minimum	22.4	13.6	22.4	13.6
Maximum	47.5	21.8	47.5	21.8
Sum	216.4	103.2	216.4	103.2
Count	6	6	6	6
Confidence Level (95.0%)	9.244251	3.337139	9.244251	3.337139

The model allows a user to enter any desired combination of PPE and sanitation items that data have been collected on, and reports how much time should be required for the desired donning & doffing combinations. The model takes values [mean, lower confidence limit (LCL) & upper confidence limit (UCL)] from each of the worksheets containing data on various items and uses them in the statistical calculations. The user can select “Raw Data” or “Filtered Data” where the “Filtered Data” has the outliers removed from the “Raw Data” before the statistics are calculated. In Figure 29, a representative selection page for the model is shown. On this page, multiple items of PPE have been selected and “Filtered Data” has also

been selected. A calculation section of the model is shown in Figure 30 for don times of the selections made on the user screen in Figure 29. The calculation section for doff times for the same user screen is shown in Figure 31. The example does not represent a typical group of PPE that would be worn by a single employee, but rather is shown to demonstrate how the model is used.

Figure 29. *User Page of Excel Model to Select PPE*

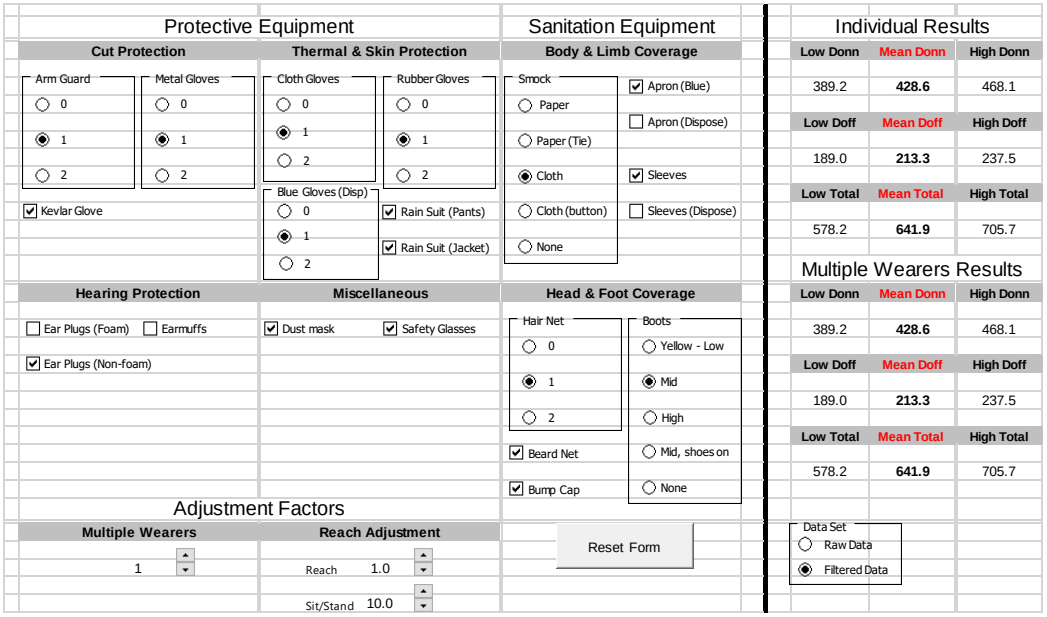

Figure 30. *Excel Model – Don Data*

Don								
			Filtered Low	Filtered	Filtered High	Raw Low	Raw	Raw High
Rubber Gloves	1		9.54	10.00	10.46	10.33	11.14	11.96
Cloth Gloves	1		8.50	8.93	9.35	9.48	10.23	10.97
Metal Mesh Golves	1		14.11	21.26	28.40	14.11	21.26	28.40
Kevlar Glove	TRUE		7.81	8.49	9.17	8.16	9.18	10.19
Ear Plugs (Non-foam)	TRUE		12.59	13.70	14.81	13.31	14.88	16.45
Safety Glasses	TRUE		7.36	8.30	9.25	7.67	8.86	10.05
Apron (Disposable)	TRUE		50.40	52.92	55.44	51.17	54.36	57.55
Dust mask	TRUE		5.71	8.37	11.02	-2.79	13.45	29.69
Ear plugs	TRUE		14.94	16.64	18.33	15.42	17.32	19.22
Ear muffs	TRUE		3.86	4.45	5.04	4.19	5.06	5.93
Arm Guard	1		4.56	4.92	5.29	5.00	5.79	6.58
Boots	2		44.99	51.64	58.29	49.01	57.68	66.35
Blue Gloves	1		11.97	12.72	13.47	12.40	13.35	14.29
Apron (Blue)	TRUE		23.28	24.22	25.16	24.23	25.46	26.69
Beard net	TRUE		11.89	12.78	13.67	11.89	12.78	13.67
Hair net	1		13.75	14.62	15.50	14.10	15.06	16.02
Sleeves	TRUE		57.44	60.07	62.69	66.07	71.15	76.22
Bump Cap	TRUE		5.32	6.09	6.86	5.44	6.35	7.26
Rain Suit (Pants)	TRUE		49.14	56.17	63.20	49.14	56.17	63.20
Rain Suit (Jacket)	TRUE		38.12	42.12	46.12	38.74	43.38	48.02
Sleeves (Disposable)	TRUE		22.68	24.62	26.55	23.75	26.05	28.36
Smock	3		33.07	34.24	35.41	34.23	35.82	37.41

Figure 31. *Excel Model – Doff Data*

Doff								
			Filtered Low	Filtered	Filtered High	Raw Low	Raw	Raw High
Rubber Gloves	1		4.97	5.32	5.67	5.24	5.69	6.14
Cloth Gloves	1		4.55	4.89	5.22	4.83	5.25	5.68
Metal Mesh Golves	1		4.61	6.52	8.43	4.61	6.52	8.43
Kevlar Glove	TRUE		5.14	5.81	6.47	5.23	5.92	6.62
Ear Plugs (Non-foam)	TRUE		5.60	6.08	6.57	6.37	7.54	8.71
Safety Glasses	TRUE		4.24	4.72	5.20	4.31	4.91	5.51
Apron (Disposable)	TRUE		6.71	7.38	8.05	7.03	7.90	8.77
Dust mask	TRUE		0.88	5.30	9.72	0.88	5.30	9.72
Ear plugs	TRUE		5.30	5.87	6.44	6.05	7.61	9.16
Ear muffs	TRUE		2.82	3.22	3.63	3.03	3.56	4.08
Arm Guard	1		3.72	3.91	4.11	3.80	4.04	4.28
Boots	2		26.94	31.65	36.37	29.16	36.27	43.37
Blue Gloves	1		4.41	4.94	5.46	4.81	5.57	6.32
Apron (Blue)	TRUE		11.57	12.11	12.65	12.51	13.58	14.65
Beard net	TRUE		4.62	4.94	5.25	4.92	5.62	6.32
Hair net	1		5.24	5.55	5.87	5.60	6.00	6.40
Sleeves	TRUE		18.24	19.10	19.96	19.92	21.96	24.01
Bump Cap	TRUE		3.65	4.07	4.50	3.71	4.23	4.74
Rain Suit (Pants)	TRUE		24.05	29.40	34.74	24.20	36.72	49.23
Rain Suit (Jacket)	TRUE		13.42	15.20	16.99	14.01	16.15	18.29
Sleeves (Disposable)	TRUE		7.53	8.24	8.95	7.73	8.76	9.79
Smock	3		13.17	13.78	14.38	13.78	14.60	15.41

Validation

In order to validate the model output, the times obtained from the time study of fifty-nine (59) subjects donning and doffing 936 pieces of PPE and sanitation equipment were compared to those housed in the database for similar equipment. As seen in Table 1, the model conservatively overestimates the time (cmin) it actually took (observed) for the subjects to don and doff the items by an average of six percent (6%), 3% for don and 9% for doff.

Table 1. *PPE Donning/Doffing Validation Results*

	Don			**Doff**		
PPE	**Timed Data**	**Model**	**% Diff**	**Timed Data**	**Model**	**% Diff**
Earplugs	14.2	14.7	3%	7.2	7.1	-1%
Hair net	11.3	15.6	28%	5.3	6.6	20%
Beard net	12.5	13.8	9%	5.5	5.9	7%
Smock	32.8	35.2	7%	13.6	14.8	8%
Bump Cap	7.1	7.1	0%	4.9	5.1	4%
Chain Glove	12.9	22.3	42%	6.2	7.5	17%
Kevlar Glove	11.3	9.5	-19%	5.3	6.8	22%
Apron	25.9	25.2	-3%	12.1	13.1	8%
Cloth Glove	9.8	9.9	1%	5.4	5.9	8%
Rubber Glove	15.1	11.0	-37%	6.7	6.3	-6%
Mean Diff			**3%**			**9%**

The model is of great utility in determining how long it should take to don and doff various combinations of PPE and sanitary gear. A user can simply click on the appropriate items being considered, the model retrieves the values that are needed from the data spreadsheets, and returns an interval that contains the estimated time to accomplish the don & doff sequence. Of the three values reported, the mean is most appropriately used to represent the correct time. Use of the upper confidence limit is highly conservative, while using the lower confidence limit would be very liberal.

Model Case Study

A poultry processing facility in the US desired to know how much time its employees should be spending daily on donning/doffing PPE and sanitation items associated with their jobs. The facility contained numerous departments, encompassing one hundred forty-one (141) unique job descriptions (excluding maintenance), employing one thousand (1,000) individuals over two shifts. The first step in determining the don & doff time for any of the 141 discrete jobs was to work with management to develop a list of the PPE and sanitation items required for each job. It is important to note the term "required". There can exist a significant difference in what PPE, sanitation equipment, and even personal clothing items an employee chooses to wear, and those items deemed required by the employer for various reasons, such as safety issues mandated by the Occupational Safety and Health Administration (OSHA), food safety concerns such as Hazard Analysis and Critical Control Points (HAACP), Good Manufacturing Practice (GMP) and contractual concerns (potential union issues), among others. When determining what items to add to the model, only those items identified as required in the PPE/Sanitation Equipment Matrix (Figure 32) were added.

Figure 32. *PPE/Sanitation Equipment Matrix*

					Gloves													
Dept.	No. Empl.	Smock	Boots	Bump Cap	Rubber	Cotton	Cutting	Steel	Arm Guard	Sleeves	Apron	Glasses	Ear Plugs	Hair Net	Dust Mask	Safety Vest	Cover-alls
Giblets																		
Heart Puller	3	X	X	Orange	X	X				X	X	X	X	X			
Liver	2	X	X	Orange	X	X				X	X	X	X	X			
Heart	1	X	X	Orange	X	X				X	X	X	X	X			
Gizzard	1	X	X	Orange	X	X				X	X	X	X	X			
Gizzard Scaler	1	X	X	Orange	X	X				X	X	X	X	X			
Gizzard Packer	1	X	X	Orange	X	X				X	X	X	X	X			
Heart/Liver/Lung Chiller	1	X	X	Orange	X	X				X	X	X	X	X			
Floor Person	1	X	X	Red	X	X				X	X	X	X	X			
Line Leader	1	X	X	Orange	X	X				X	X	X	X	X			
Ice	1	X	X	Orange	X	X				X	X	X	X	X			
Neck Chiller	1	X	X	Orange	X	X				X	X	X	X	X			
Grading & Rehang																		
Rehanger	22	X	X	Orange	X	X				X	X	X	X	X			
Saw Operator	2	X	X	Orange	X	X		X	X	X	X	X	X	X			
Line Leader	1	X	X	Orange	X	X				X	X	X	X	X			
Floor person	2	X	X	Red	X	X					X	X	X	X			
Jack Driver	1	X	X	Orange	X	X						X	X	X			
Reconditioner	1	X	X	Orange	X	X				X	X	X	X	X			
PEDCO Sizer	2	X	X	Orange	X	X						X	X	X			
Thigh Debone																		
Hanger	4	X	X	Green	X	X				X	X		X	X			
Cutter	16	X	X	Green	X	X	X	X		X	X		X	X			
Trimmer	16	X	X	Green	X	X	X	X		X	X		X	X			
Line Leader	4	X	X	Green	X	X				X	X		X	X			
Scaler	2	X	X	Green	X	X				X	X		X	X			
Strapper	1	X	X	Green		X							X	X			
Packer	3	X	X	Green	X	X				X	X		X	X			
Grader	3	X	X	Green	X	X				X	X		X	X			
Singulator	1	X	X	Green	X	X				X	X		X	X			
CVP Operator	1	X	X	Green		X							X	X			
Floor Person	2	X	X	Red	X	X							X	X			
Box Maker	1	X	X	Green		X							X	X			
Box Room																		
Box Room Employees	5	X	X	Grey									x	x			

The individual required items of PPE and sanitation equipment were entered into the model, outputting the estimated time to don & doff this specific combination. These times were entered into a spreadsheet, multiplied by the number of employees in that job title (all shifts), and summed across all 141 jobs. This grand sum is divided by the total number of employees (1000 in this case), resulting in the time it takes the average employee to don & doff (a single time). This time is multiplied by three (3) to represent the three times per day that the employees don & doff their equipment. An adjustment is made to allow for only a single don and doff of the hair net, as it remains on the employee's head during all break periods.

The output of this procedure results in the average employee spending slightly less than 4 minutes (3.97) per shift donning and doffing the required equipment. An additional use of the model may be the determination of which specific jobs, and the associated number of affected employees, might exceed a particular threshold of interest to the company. Say the company wanted to know what percentage (or exact number) of employees exceeding ten (10) total minutes per workday donning and doffing. The model could easily provide answers to such questions.

It should also be noted that no accommodation has been used in the model to account for simultaneous operations. Meaning, the vast majority of the PPE and sanitation equipment could be donned/doffed while walking to and from the job without significantly impacting either the walking time or the don/doff time.

Self-Reporting

When asked, "How long does it typically take you to put on (don) the PPE and sanitation items that you just were timed on?", the mean answer was 211.7 seconds. For the "How long does it typically take you to take off (doff) the PPE and sanitation items that you just were timed on?" question, the mean answer was 139.4 seconds.

The time donning and doffing PPE and sanitary gear (single time) was self-reported by the subjects as being 351.1 seconds or 5.85 minutes. It is also interesting to determine whether or not individuals underestimated, nearly correctly estimated, or overestimated how much time it takes to don and doff these PPE and sanitation items. To determine this, the specific combinations of items in which each subject was tested (timed from the video), was compared to their self-reported estimate about how long it took them to don and doff the same items.

Table 2. *Self-Reported Donning/Doffing Times*

Self-Reported Time Estimation (n=59)				
Estimation	Under Estimate	Correctly Estimate*	Over Estimate	Average % Off
Don	15.3%	8.5%	76.2%	231%
Doff	8.5%	5.1%	86.4%	360%

*Subjects were deemed to provide a 'Correct Estimate' if they reported a value within +/- 15% of the actual time it took to don and doff.

These results (shown in Table 2) suggest that the vast majority of subjects (81.3%) tend to over-estimate the time that it takes to don and doff PPE and sanitation equipment. Though it is interesting in itself to note this tendency to overestimate, the magnitude of the over estimation is of interest.

When donning items, individuals reported that it took 231% of the actual measured time to accomplish this task. In other words, if it actually took an individual 1-minute to correctly don the items, they reported on the average that it took approximately 2 minutes and 18 seconds. The actual observed mean time to don the items that they normally wear (sanitation and PPE) across all 59 observed employees, was slightly more than 1.5 minutes (153.0 cmin).

When doffing items, individuals reported that it took 360% of the actual measured time to accomplish this task. In other words, if it actually took an individual 1-minute to correctly doff the items, they reported on the average that it took approximately 3 minutes and 35 seconds. The actual observed mean time to doff the items that they normally wear (sanitation and PPE) across all 59 observed employees was approximately 39 seconds (64.8 cmin).

Having directly observed and timed fifty-nine (59) employees' (subjects') don and doff the actual sanitation gear and PPE they choose to normally wear in the course of their jobs, the mean time to don and doff all of the equipment, for those employees observed, was 2 minutes and 11 seconds. When asked how long it takes for them to don and doff the exact same combination of equipment, the subjects' answered an average of 5

minutes and 51 seconds. Taking the employees self-reported time of 351.1 seconds and dividing by the observed time of 130.7 seconds, results in a factor of roughly 2.7, or 270% over-estimation.

Conclusions

This study shows that classical time studies can be used to empirically establish statistically sound donning and doffing times. MOST can be used by an experienced analyst to validate such time studies or in lieu of such studies. The model (based on factual data) developed and validated for this study provides a superior, unbiased, easy to use, objective approach to provide any interested party with the ability to accurately determine how much time should be allocated to a donning or doffing (limited to the items contained in the model) sequence. The model output for the case study resulted in the average employee spending slightly less than 4 minutes (3.97) per shift donning and doffing the required equipment, significantly less time than the employees (subjects) tended to self-report.

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