

## Supplemental Tables and Figures for

**Title:** Derivation of time-activity data using wearable cameras and measures of personal inhalation exposure among workers at an informal electronic-waste recovery site in Ghana

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## Table S1: Dictionary of e-waste related activities

- 1) *Burning*: valuable e-waste components covered in plastics are placed into open, surface fires to melt away the unwanted plastics. Metal rods are a tool used during burning to turn and move metal in and out of the fire.
- 2) *Dismantling*: e-waste is manually dismantled using physical force and tools including hammer, chisel, screwdriver, pliers and cutters. We included wire stripping in the dismantling category as it is typically performed in the same setting or adjacent to dismantling tasks.
- 3) *Sorting*: like e-waste parts and components are sorted into piles and put into sacks either for further processing, burning or selling.
- 4) *On-Off loading*: e-waste and scraps are loaded on and off-carts and wheel barrows following collection or processing to be moved from one location to another.
- 5) *Buying/trading*: collected (unprocessed) e-waste or recovered metals (predominantly copper, aluminum and steel) and valuable parts are purchased for e-waste processing or selling at a market. Exchange of money and goods were used to identify buying and trading.
- 6) *Weighing*: weighing or “scaling” is performed on site to determine the weight of the final product to be sold (typically copper, steel or aluminum). Weigh stations (large scales) are identifiable in the images.
- 7) *Transporting materials* can be done on or off-site. When performed off-site, materials are collected or “scavenged” from neighborhoods in Accra for free or a nominal fee. This work is typically performed using a cart, however items are also picked up by bicycle/tricycle or automated vehicles. We indicated if a worker was “transporting materials” if he was either walking, bicycling, or on a motorbike and visibly carrying or pushing e-waste materials. Location can’t be determined.
- 8) *Repairing* electronic or electrical devices for resale or personal use.
- 9) *Smelting* metals including aluminum or lead are performed on-site. Workers reported that smelting lead used to occur more frequently at Agbogbloshie, but is now rare.

Table S2: Chronology of activities and output for processing wearable camera images

Step	Activity	Output	Location
1	Visit and observe physical worksite	List of specific tasks and their associated visual cues; If possible, a map of the primary work space's general layout and major landmarks.	Field
2	Deploy wearable cameras to capture images	Participant specific folders with time-stamped images.	Field
3	Use output from step 1 and descriptions of the work processes from previous literature to inform a preliminary screening of a subset of digital images.	Lists of identifiable tasks (i.e. work, non-work and transportation related), common behaviors and themes; List of objects and landmarks predictive of task and exposure; Method for the use of objects and landmarks to validate assignment and predict exposure; And list of image quality issues. Process complete when no new visual themes are identified by reviewing additional images (saturation).	Office
4	Design a data collection instrument using output from steps 1 and 3.	Data collection instrument with each entry representing one event-unit. Skip logic and quality controls are recommended to streamline the process and improve data entry results.	Office
5	Design training materials	Training materials with exemplar images for each specific task assignment and data entry protocol.	Office
6	Train reviewers and perform pilot data entry	Database of task sequence and task-specific details for a subset of participants.	Office
7	Return to physical worksite and meet with workers to review accuracy of task assignment using exemplar images.	Agreement between worker and reviewer assigned tasks.	Field
8	Use results from step 7 to revise data collection instrument and update training.	Modified training protocol and data collection instrument.	Office
9	Perform single or double data entry.	Database of task sequence and task-specific details for all study participants.	Office
10	Export final database to render TAPS and merge with contemporaneous exposure estimates.	Minute-by-minute database of event sequence, a time-activity pattern (TAP) and contemporaneous PM <sub>2.5</sub> concentration.	Office
11	Program a method for averaging the database to render TAPs with desired time-resolution.	Averaged database of time-resolved TAPs. For the averaged 5-min database a minimum of three minutes/images were required. The event chosen to represent the averaged unit was performed most in the interval. Equally split intervals choose the first of the two activities. A similar protocol was followed to create an averaged database with a 30-min resolution, however the selection criteria prioritized work-related activities even if other non-	Office

work related events had a longer duration in the same time interval.

Table S3: Socio-demographic and job characteristics of e-waste worker participants (n=141).

<b>Characteristic</b>		<b>Overall</b>
<b>Sex (%)</b>	Male	141 (100.0)
<b>Age (mean (range))</b>		26.9 (16-50)
<b>Country (%)</b>	Ghana	138 (97.9)
	Other	3 (2.1)
<b>Region (%)</b>	Northern	3 (2.1)
	Other	136 (96.5)
<b>Language (%)</b>	Dagbani	5 (3.5)
	Other	130 (92.2)
	Missing	6 (4.3)
<b>Religion (%)</b>	Muslim	5 (3.5)
	Other	132 (93.6)
	No religion	6 (4.3)
<b>Marital status (%)</b>	Married	3 (2.1)
	Single	80 (56.7)
	Other	56 (39.7)
	Missing	2 (1.4)
<b>Education (%)</b>	No education	3 (2.1)
	Primary education	45 (31.9)
	Junior secondary school	37 (26.2)
	Secondary school	41 (29.1)
	Higher	16 (11.3)
	Missing	1 (0.7)
<b>Daily Income (%) 4GHS= 1USD</b>	<= GHS 20	1 (0.7)
	GHS 21-40	26 (18.4)
	GHS 41-60	46 (32.6)
	GHS 61-100	38 (27.0)
	>100 GHS	14 (9.9)
<b>Home location (%)</b>	On or within 1km of e-waste site	17 (12.1)
	Off e-waste site(> 1km)	124 (87.9)
	Missing	15 (10.6)
<b>Years at Agbogbloshie (mean (range))</b>	8.62 (.08-25)	2 (1.4)
<b>Hours worked/ day (mean (range))</b>		
<b>Work on Saturday or Sunday (%)</b>	Rarely	9.58 (4-15)
	Frequently	12 (8.5)
	Always	21 (14.9)
	Missing	102 (72.3)

Table S4: Worker self-reported job task history since arriving to the Agbogbloshie e-waste recovery site (n=141)

Tasks	"Ever" performed job	"Currently" perform job	Primary job in the past 3 months <sup>a</sup>	Primary job in the past 1 month <sup>a</sup>	Months ever performing job Mean (range)	No of days in past week performing job Mean (range)	No of hr during last work day performing job Mean (range)
Burning e-waste	84 (59.6)	82 (58.2)	26 (18.4)	23 (16.3)	67.9 (1-216)	4.0 (1-7)	3.5 (1-13)
Dismantling	111 (78.7)	104 (73.8)	52 (36.9)	60 (42.6)	83.9 (1-253)	4.1 (1-7)	4.8 (1-13)
Collecting e-waste	65 (46.1)	53 (37.6)	19 (13.5)	17 (12.1)	71.9 (1-253)	3.7 (1-7)	4.4 (1-13)
Sorting	54 (38.3)	48 (34.0)	1 (0.7)	1 (0.7)	73.2 (1-253)	2.8 (1-7)	1.8 (1-5)
Trading, selling	89 (63.1)	85 (60.3)	24 (17.0)	21 (14.9)	107.8 (1-265)	3.8 (1-7)	3.6 (1-13)
Weighing	6 (4.3)	6 (4.3)	2 (1.4)	4 (2.8)	71.6 (8-149)	6.3 (6-7)	7. (2-12)
Repairing electronics	14 (9.9)	13 (9.2)	2 (1.4)	3 (2.1)	79.8 (9-228)	3.5 (1-7)	3.7 (1-10)
Smelting	12 (8.5)	12 (8.5)	0 (0.0)	0 (0.0)	75.9 (2-216)	1.6 (1-3)	2.3 (1-4)
Other	9 (6.4)	7 (5.0)	10 (7.1)	7 (5.)	32.6 (2-100)	1.3 (1-21)	8.9 (3-13)

<sup>a</sup> Column does not add to total due to missing (n=5).

Table S5: Distribution of event duration by activity type (image-based).

	Events <sup>a</sup>	Duration in minutes			
	N	min	med	mean	max
<b>Work-related events</b>					
Burning	26	7	33.5	47.7	147
Dismantling	75	2	33.0	58.2	275
Sorting and loading	43	1	17.0	34.5	170
Buy, sell, weigh transporting materials	16	3	17.0	18.6	49
Repair	40	1	13.5	21.3	90
Other	1	16	16.0	16.0	16
	11	13	48.0	50.6	94
<b>Non-Work related events</b>					
Sitting	260	1	35.5	56.4	282
Smoking while sitting	24	8	33.5	43.4	228
Eating or drinking while sitting	44	7	15.5	23.5	155
Other	16	1	17.5	20.5	71
<b>Transportation related events</b>					
Walking	256	1	14.0	16.1	63
Bicycling	28	6	18.5	20.5	51
Motorbike or Car	70	1	8.5	18.0	164

<sup>a</sup> An event<sup>”</sup> is defined as a consecutive series of images of variable length depicting one sustained activity; event duration can range from 1 to  $n$  minutes in length.

Table S6: Summary of size-specific particulate matter by activity type (image-based).

Category	No. of 5-min periods N (%)	PM 1 (µg/m3)			COARSE PM (µg/m3)			Total Suspended Particulate		
		GM (SD)	Mean	Median	GM (SD)	Mean	Median	GM (SD)	Mean	Median
<b>Work related events</b>	<b>1757 (28.2)</b>	<b>47. (2.)</b>	<b>59.2</b>	<b>48.4</b>	<b>105.8 (2.5)</b>	<b>167.3</b>	<b>97.1</b>	<b>214.6 (2.2)</b>	<b>312.5</b>	<b>196.4</b>
Burning	249 (4.0)	47.5 (2.2)	63.0	48.0	111.9 (3.1)	235.3	90.3	238.7 (2.9)	462.2	189.4
Dismantling	864 (13.8)	48.3 (1.9)	59.0	50.2	104.3 (2.1)	144.6	97.9	208.7 (2.)	269.9	196.4
Collect, sort, load	301 (4.8)	53.8 (1.9)	67.4	55.2	108.7 (2.5)	170.5	95.3	228.6 (2.2)	324.1	199.6
Buy, sell, weigh	61 (1.0)	39. (2.2)	51.2	51.6	77.2 (3.7)	155.7	106.1	156.6 (2.9)	253.8	175.0
transporting materials	169 (2.7)	37.8 (2.1)	50.7	34.8	112.6 (2.6)	180.1	108.9	216.5 (2.4)	321.2	197.6
Repair	3 (0.0)	41.1 (1.1)	41.1	40.7	86.5 (2.)	102.9	62.0	152.7 (1.9)	176.3	111.4
Other (work)	110 (1.8)	39.8 (1.9)	47.8	39.4	105.1 (2.9)	171.6	98.1	209.7 (2.4)	299.5	193.7
<b>Non-Work related events</b>	<b>3311 (53.1)</b>	<b>47.3 (2.1)</b>	<b>61.6</b>	<b>49.6</b>	<b>66.6 (2.3)</b>	<b>99.0</b>	<b>67.5</b>	<b>149.3 (2.)</b>	<b>196.2</b>	<b>152.8</b>
Sitting	2836 (45.5)	47.2 (2.1)	60.9	49.9	66.1 (2.3)	97.8	66.8	147.2 (2.)	193.4	150.8
Smoking while sitting	210 (3.4)	57.1 (2.3)	80.0	60.2	55.8 (2.1)	72.0	62.8	148.4 (1.9)	179.7	163.3
Eating or drinking while sitting	201 (3.2)	41.6 (2.1)	55.3	39.5	78.8 (2.4)	117.2	73.5	170.4 (2.1)	223.7	164.5
Other (non-work)	64 (1.0)	38.9 (2.2)	52.6	36.3	101.5 (2.6)	183.0	93.0	189.5 (2.3)	287.5	182.8
<b>Transportation related events</b>	<b>1171 (18.8)</b>	<b>47.4 (2.1)</b>	<b>62.8</b>	<b>48.2</b>	<b>89.2 (2.4)</b>	<b>134.2</b>	<b>92.7</b>	<b>187.9 (2.1)</b>	<b>251.6</b>	<b>191.7</b>
Walking	807 (12.9)	52.3 (2.1)	69.0	53.2	90.7 (2.3)	129.6	93.7	193.6 (2.)	250.1	196.0
Bicycling	115 (1.8)	43.2 (2.)	54.6	43.6	93.6 (2.3)	128.2	100.7	177.7 (2.)	224.6	172.9
Motorbike or Car	249 (4.0)	36.1 (2.)	46.5	33.9	82.6 (3.)	151.8	80.6	175.2 (2.5)	269.0	172.1
<b>Total</b>	<b>6239 (100)</b>	<b>47.2 (2.1)</b>	<b>61.1</b>	<b>48.8</b>	<b>80.2 (2.4)</b>	<b>124.9</b>	<b>78.7</b>	<b>172.7 (2.1)</b>	<b>239.3</b>	<b>171.1</b>

Fig S1: Data collection and sampling framework

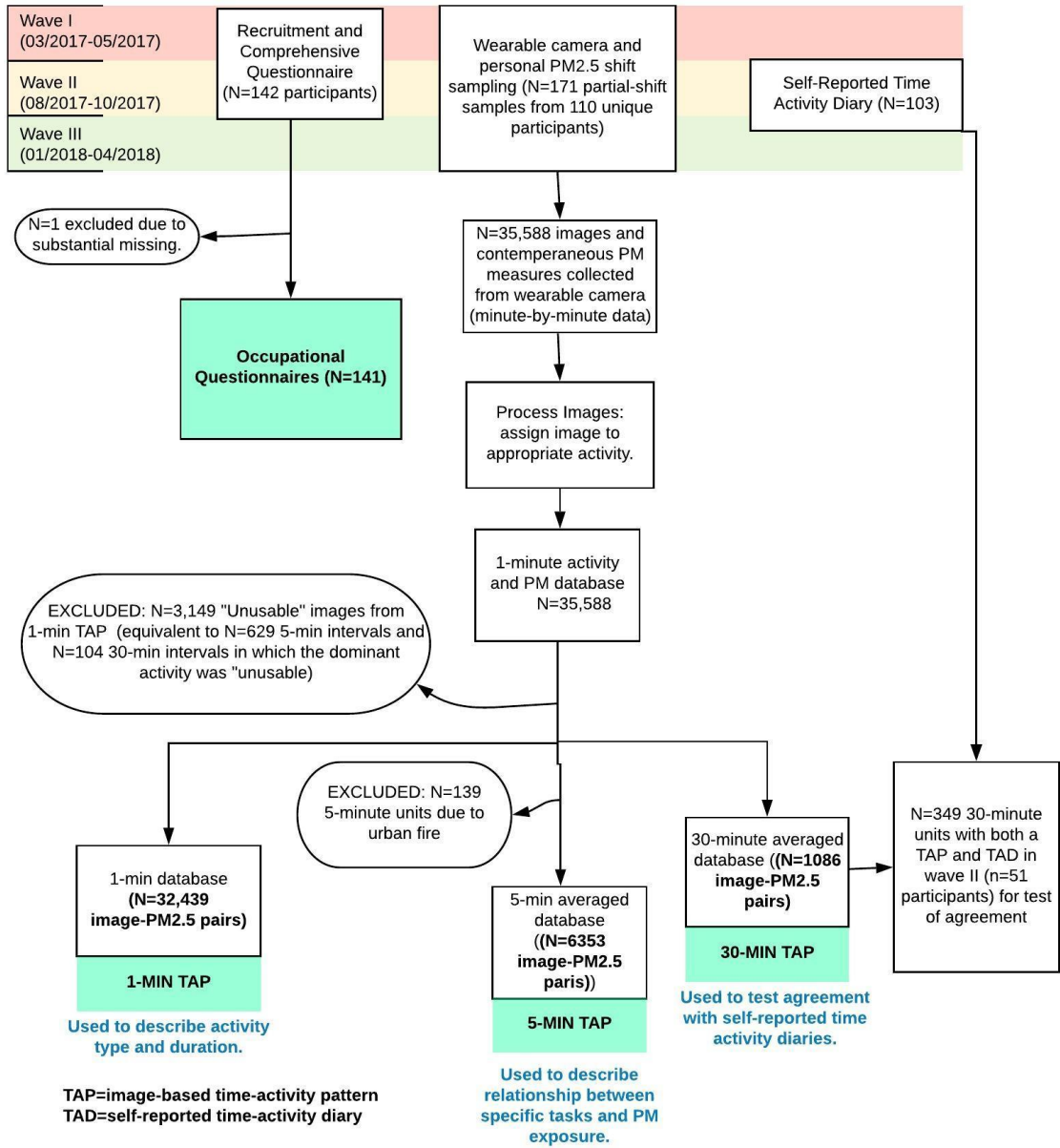




Fig S2: Self-reported time-activity diary

	Non-Work Activity (Pray, Eat, Break)	Repair electronics	Collect or Off-Load e-waste	Dismantle e-waste	Remove covering from wires	Sort e-waste	Burn e-waste	Burn wires only	Collect wires after burning	Trade or sell e- waste	Smelt lead batteries	Other T Type 1 (specify):	Other T Type 2 (specify):
6:00 -													
6:30 -													
7:00 -													
7:30 -													
8:00 -													
8:30 -													
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Details on task categories used to test agreement with image-based time-activity data: Prior to testing the agreement between self-reported and image-based time-activity data, specific job categories were combined. These categories were created by combining activities that shared certain identifiable visual cues (e.g. visible open flames), physical effort, and materials. Agreement was tested for the following categories: burning, dismantling, material movement and organization, buy-sell-weigh, repairing, smelting, other (work-related), and non-work-related.

From the self-reported diaries *Burning* is comprised of “burn e-waste”, “burn wires only” and “collect wires after burning”; *Material movement and transport* is comprised of “collect or off-load e-waste” and “sort e-waste”; *Dismantling* is comprised of “dismantle e-waste” and “remove covering from wires”; *Buy-sell-weigh* is comprised of “trade of sell e-waste” and “weighing e-waste” which was written into the “other (work)” category. All other categorizes remained unchanged.

From the image-based data collection tool: *Burning* is comprised of “burning wires”, “burning material other than wires”, and “starting or igniting a fire”; *Dismantling* is comprised of “dismantling, pounding or breaking”, and “stripping casings off of wires”; *Material movement and organization* is comprised of “on-/off-loading”, “sorting, gathering”, and “transporting materials”; *Buy-sell-weigh* is comprised of “trading or selling e-waste” and “weighing”. All other categorizes remained unchanged.

Fig S3: Instrument for collecting data from time-lapse images.

Confidential

Data Collection Instrument for wearable camera images  
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## Data collection instrument for processing wearable camera images

---

Participant ID

What Participant ID are you working on?  
Enter the participant ID (exactly how it is labeled  
in MBox):

\_\_\_\_\_ (enter all 5 digits of the new ID)

---

Enter the GoPro ID that corresponds with the START of  
this activity (ex. G0012671):

\_\_\_\_\_ (example: G0012671)

---

Enter the GoPro ID that corresponds with the END of  
this activity (ex. G0012671):

\_\_\_\_\_ (example G0012671)

---

Choose a PIVOTAL photo for this activity.  
Enter the GoPro ID that corresponds with the PIVOTAL  
photo (ex. G0012671):

\_\_\_\_\_ (example: G0012671)

A pivotal photo is the photo that helped you pick out  
the activity you are about to describe.

---

**What is the activity?**

---

---

Scan the list of activities below and think about whether the subject wearing the camera is engaged in a task related to their work (WORK TASK), is doing something else (OTHER tasks) or is in-between tasks (TRANSPORT).

- Work task
- Other task
- Transport or In-Between tasks
- Backpack with camera removed
- Staging area

**Work Tasks:**

Burning (any kind)  
Wire Stripping  
Dismantling, pounding, breaking  
Repairing  
On- or Off-Loading,  
Gathering, sorting  
Trading, selling, weighing  
Smelting (any material)

**Other Tasks:**

On a break  
Praying  
Eating or drinking  
Taking a nap  
Communicating with others/ on the Cell Phone  
In the washroom  
Other

**Transport or In-Between tasks:**

Subject is on the move

**Staging Area:**

Getting the backpack on, off or adjusted

---

**WORK RELATED ACTIVITY**

Which task best describes what they are doing?

- Burning wires
  - Burning material other than wires
  - Starting or igniting a fire
  - Stripping casings off of wires
  - Dismantling, pounding, breaking
  - Repairing an electronic (may be hard to tell, but ultimate goal is not to break it apart)
  - On- or Off-Loading
  - Sorting, gathering
  - Weighing
  - Trading or Selling
  - Smelting (melting something in a pot over flames)
  - Other
- (Check ALL that apply)

---

Since you indicated "other", please describe:

\_\_\_\_\_

What fuel source is being used to get the fire going?

- Styrofoam
  - Petrol/kerosene
  - Tires
  - Only lighters and matches
  - Saw dust
  - Coconut Shells
  - Other
  - I can't tell
- (Check ALL that apply)

Since you indicated "other", please describe:

\_\_\_\_\_

How confident are you that the subject is doing the task you described: "[task\_1]"?

Low confidence      Medium confidence      High confidence

=====

(Place a mark on the scale above)

### NON-WORK RELATED ACTIVITY

Which of these activities best describe the "[task]" that the subject is engaged in?

- Smoking
  - Eating, drinking
  - Praying
  - Rest, Cell Phone, communicating
  - In the washroom
  - Cooking
  - Shopping or at the market
  - Other
- (Check ALL that apply)

Since you indicated "other", please describe:

\_\_\_\_\_

Are people performing any type of e-waste recycling nearby?

- Yes
- No

### TRANSPORTATION RELATED

What type of transportation method is the participant engaged in?

- Walking
- Riding a bicycle
- Riding a motorbike
- Sitting or driving in an automobile (car, bus, truck)
- I am not sure

Is the subject moving work materials by carrying them or pushing/pulling a cart?

- Yes
- No
- I'm not sure

## OBJECT SEARCH

Do you see any of these objects throughout this activity?

If you like, you can list objects found in other photos related to this task.

- Fire
  - Smoke
  - Ash
  - Pot over flames
  - Indoor Cook Stove that is being used
  - Cigarette or someone smoking
  - Tools (hammer, chisel, fire poker)
  - Wires, copper wires, wire casings
  - Electronic or car parts (can be broken)
  - Metal shavings, chunks or pieces
  - Sack with metal or parts
  - Scale or weigh station
  - Wheelbarrow or cart
  - Moving motorbike or automobiles
  - Food or drink
  - Market, shop or food vendor
  - NONE OF THE ABOVE
- (Check ALL that apply)

How close is the participant to the FIRE or SMOKE?  
(Choose the BEST match)

- Very close/ In the smoke
- A few body lengths away
- 10 meters or farther
- I can't tell

## NEW SECTION: IMMEDIATE SURROUNDINGS OR "MICRO-ENVIRONMENT"

For this activity (even if you are not completely sure what it is), which category best describes the immediate surroundings of the participant during this task?

- Completely outdoors (no roof or any walls)
- Completely indoors (all windows and doors are closed)
- Partially indoors (could include just a roof, some walls or open windows and doors)
- the participant went to multiple locations

Which location did the participant spend the most time in during this activity?

- Completely outdoors (no roof or any walls)
- Completely indoors (all windows and doors are closed)
- Partially indoors (could include just a roof, some walls or open windows and doors)

Please check off any of the following features that match the enclosure that the subject is in:

- One or more walls
  - Open window or door
  - Finished floor, carpet or rug
  - Roof (indicators may be shade or a shadow)
- (Check ALL that apply)

## All Done!

You have finished all questions for this activity

Nice Job

Use the notes box to tell us anything else you think we might want to know.

\_\_\_\_\_

When you are done, please SAVE the file, enter a new activity for this participant or go on to the next.

Figure S4: Proportion of time spent performing specific activities by PM<sub>2.5</sub> exposure group.

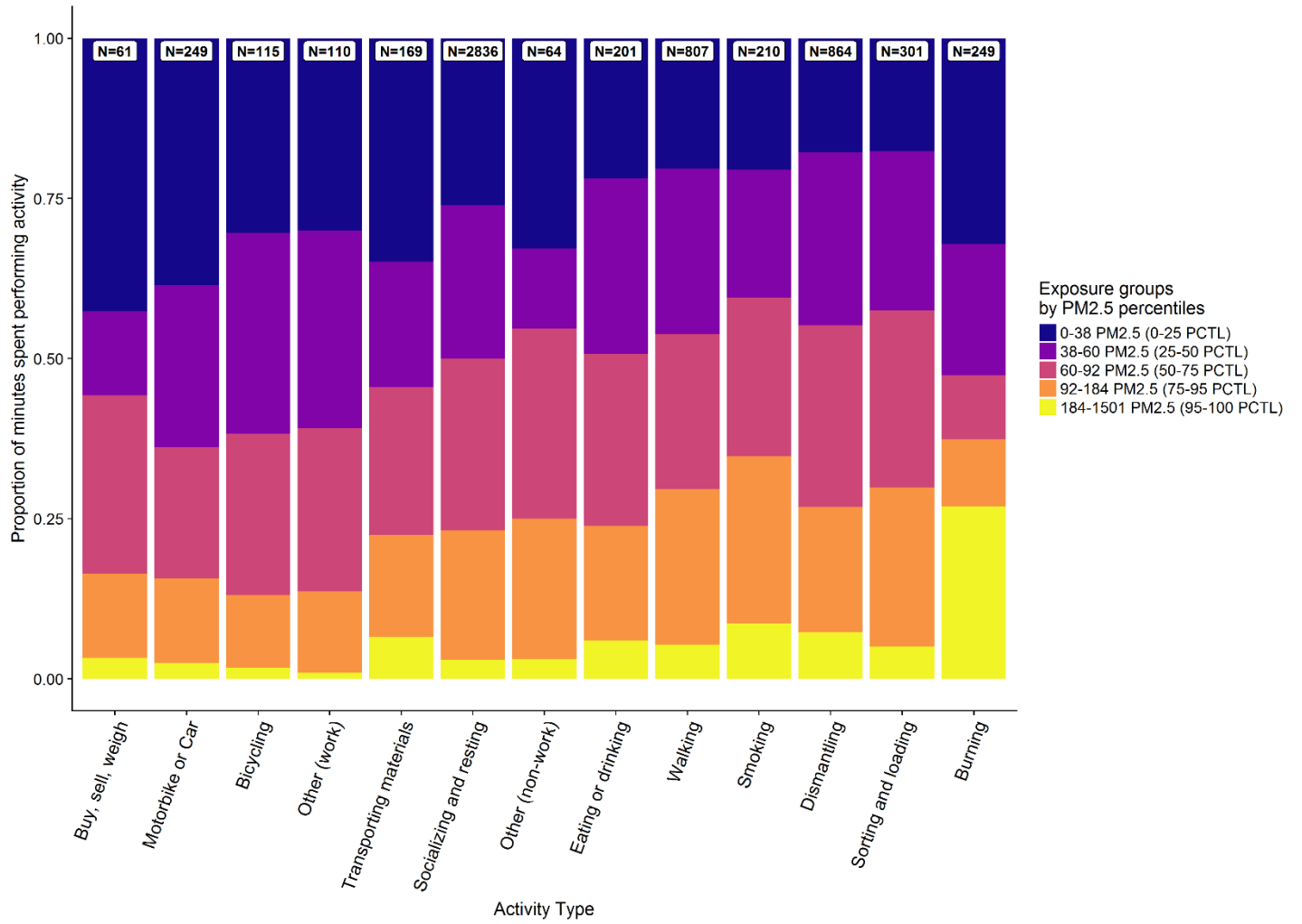


Figure S5: Images depicting burning activities characterized by high and low exposures to PM<sub>2.5</sub>



**Figure S5:** Images taken using a wide-angle GoPro Hero 4 © camera strapped to the forward facing shoulder strap of a personal sampling backpack worn by a participant in the GeoHealth study.