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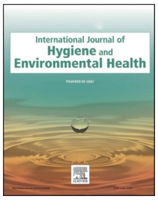

Evaluation of two-year recall of self-reported pesticide exposure among Ugandan smallholder farmers

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ABSTRACT

Objectives: To evaluate smallholder farmers' recall of pesticide use and exposure determinants over a two-year period in a low-income country context.
Methods: The Pesticide Use in Tropical Settings (PESTROP) study in Uganda consists of 302 smallholder farmers who were interviewed in 2017. In the same season in 2019, these farmers were re-questioned concerning pesticide use (e.g., use of active ingredients) and exposure information (e.g., crops, personal protective equipment [PPE], hygienic behaviours) they had previously provided. The extent of recall bias was assessed by comparing responses at follow-up in 2019 with practices and behaviours reported from the baseline interview in 2017.
Results: An 84% (n = 255) follow-up response rate was attained. We found instances of better recall (e.g., overall agreement >70% and Area Under the Curve (AUC) values > 0.7) for the use of some active ingredients, commonly used PPE items, and washing clothes after application, whereas only 13.3% could correctly recall their three major crops. We observed a trend where more individuals reported the use of active ingredients, while fewer reported the use of PPE items, two years later. In general, we found better agreement in the recall of years working with pesticides compared to hours per day or days per week in the field, with no apparent systematic over or under reporting by demographic characteristics.
Conclusions: While some of these findings provide consistency with those from high-income countries, more research is needed on recall in poorly educated agriculture communities in low- and middle-income settings to confirm these results.

What this paper adds.

What is already known about this subject?

Few studies have evaluated the recall of pesticide use in agricultural workers. These have generally found less agreement with recall when there are longer time intervals between assessments and more detailed questions used.

What are the new findings?

Smallholder farmers in Uganda could better recollect after a 2-year period the total number of years using pesticides, as well as certain active ingredients and personal protection equipment (PPE), compared to poorer recall of specific crops.

How might this impact on policy or clinical practice in the foreseeable future?

The use of pesticide products, PPE items, and years of pesticide use

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should inform exposure assessment, though additional research is needed to confirm these results with poorly educated agriculture communities in low- and middle-income settings.

1. Introduction

Global pesticide use has increased over the past 30 years, with approximately 4 million tonnes of active ingredient applied annually in recent years (Food and Agriculture Orga, 2020). The application of these pesticides in an occupational setting has been linked to an increasing range of cancer (Alavanja and Bonner, 2012), respiratory (Ye et al., 2013; Negatu et al., 2017; Hansen et al., 2021a), neurological (van der Mark et al., 2012; Negatu et al., 2018; Fuhrimann et al., 2021a), and other (Blair et al., 2014) adverse health outcomes.

A recent systematic review on occupational pesticide exposure studies published between 1993 and 2017 found that in nearly 1300 papers, approximately five times as many studies were based on indirect (e.g., self-reported) compared to direct (e.g., biomonitoring) exposure assessment methods (EAMs) (Ohlander et al., 2020). Moreover, from the 16 studies identified in that review from low-income country contexts, the majority (88%) used indirect exposure assessments. Direct EAMs, such as the collection of biomarkers, for example, are typically much more costly and resource intensive, presenting a particular challenge in low- and middle-income countries (LMICs) (Fuhrimann et al., 2020). The reliance on self-reported data in these settings is mainly due to a lack of spray records and other recording or monitoring systems, which could otherwise provide data on pesticide handling or user safety (Nanyunja et al., 2015). Hence, it is of utmost importance to better understand the reliability of self-reported data on recalled exposure relevant variables, such as pesticide use, PPE use, or hygienic behaviours.

Several factors can cloud recall ability in self-reported studies, such as a long interval between the event and reporting, higher complexity of information either in the content (e.g., recalling technical or detailed information) or wording of the question, and the triviality of events to the respondent (Stull et al., 2009). Unreliable reporting will result in non-differential misclassification of the exposure of individual study participants and will result in biases towards the null in studies where self-assessed exposure is associated with (self-reported) health outcomes. However, when the self-reported data is used to construct a job- or task-exposure matrix and the exposure is assigned at group level, the association between exposure and health outcome will result in little or no bias; albeit, the association will be less precise when the self-reporting is noisy (Armstrong, 1998). It is therefore important to understand the potential effect of recall bias in low-income contexts, where pesticide exposure is reported to be highest due to a lack in knowledge, attitude, and practices of safe pesticide use (Atuhaire et al., 2016) and the continuous use of highly hazardous pesticides (Jepson et al., 2020).

Few studies have validated self-reporting of pesticide use and relevant information on factors affecting exposure or examined the extent of recall bias in agricultural workers. Blair et al. (2002) compared recall of the use of specific pesticides, method of application, and time spent mixing pesticides over a one-year period in a sample of participants from Iowa, USA in the Agricultural Health Study (AHS). Hoppin et al. (2002) also used data from the AHS, comparing the reported starting decade of specific pesticide use to the registration year in the USA. Engel et al. (2001) examined recall of pesticide use in orchard workers in the USA within a ~20-year period and Lee et al. (2010) validated reported pesticide use in South Korean farmers over a 4-week period. Results of these studies suggest high concordance (>90%) in responses for ever having used pesticides, but indicate exact agreement could be as low as 40–50% for more detailed information, such as specific product or active ingredient used or frequency of application (Blair et al., 2002).

These studies represent a limited evidence base, with several published nearly two decades ago. The studies each used quite different intervals of recall, which provides a challenge to interpret and compare results of different exposure indicators. Also, this research did not examine recall of PPE use or hygiene practices and took place in just two countries (USA and South Korea); the implications are uncertain for LMICs, where workers may be poorly educated and illiterate, and where different pesticides, application methods, and personal protective equipment (PPE) may be used (Rother, 2018). For example, a study of smallholder farmers in Ethiopia found only 8% read and understood pesticide labels (Mengistie et al., 2017).

This manuscript is embedded in the "IMPRoving Exposure aSSessment methodologies for epidemiological studies on pesticides" (IMPRESS) project, which aims to improve understanding of the performance of pesticide EAMs used in epidemiological investigations, and to use this information to recommend enhancements in scientific practice for the future (Jones et al., 2020). In this paper, we assess the ability of Uganda's smallholder farmers to recall, over a two-year period, their working history related to pesticide exposure, including active ingredients used, PPE worn, and hygienic behaviour. The study group is a cohort of the "PEStIcide use in TROPical settings" (PESTROP) Project (Fuhrimann et al., 2019).

2. Methods

2.1. Study population

The PESTROP study cohort is located in Uganda, Wakiso District in the rural communities of Mende and Masulita. These smallholder farmers predominantly grow a mix of beans, maize, sweet potatoes, banana, cassava, coffee, tomatoes, and groundnuts on an average area of 3–4 acres (Staudacher et al., 2020; Diemer et al., 2020). Pesticide use in these communities has a potential to result in various negative health outcomes (Fuhrimann et al., 2021b, 2022; Hansen et al., 2020, 2021b). In the second cropping season of 2017 (October to December), 302 farmers were interviewed in a baseline study. Participants were informed of general results and provided personalized feedback on their pesticide exposure during an in-person group meeting. Exactly two years later, the same respondents were followed up under the IMPRESS study to assess their ability to recall information they had submitted at baseline, in addition to other exposure and health assessments (Fuhrimann et al., 2021b).

2.2. Data collection

We used a structured questionnaire designed to obtain insights on sociodemographic information (e.g., sex, age, education), practices of pesticide use, and corresponding protective behaviour. Staudacher et al. (2020) and the YouTube video 'Pestrop – An Ugandan Story' (https://www.youtube.com/watch?v=XhizHAtjyno) provide further details on the PESTROP cohort population and methodology at baseline. Only a few extraneous questions (for ethical and practical reasons) were excluded in the follow-up questionnaire (see Supplementary Material).

Trained research assistants administered via tablet the piloted and ethically approved tool through Open Data Kit (https://opendatakit.org). Interviews were conducted in the local dialect (Luganda) at locations of respondents' convenience, mainly at home and/or in the field. Urine samples were also collected prior to the reassessment from a subset of 86 interviewed farmers, as part of another IMPRESS study work package, which also involved questionnaire interviews.

The recall questionnaire in 2019 consisted of the following items, reflecting practices in the 12 months prior to the survey in 2017 as follows:

- Major crops (up to 3) on which they had worked;
- Average hours per day and days per week working in the field;
- Total years mixing or applying pesticides;

- Use (yes/no) of 15 different active ingredients (those most commonly reported at baseline), involving brand names of 53 pesticide products registered by Uganda's Ministry of Agriculture, Animal Industry and Fisheries;
- Use (yes/no) of 12 PPE items during pesticide application; and
- Typical time following pesticide application that they would bathe (e.g. showering, bathing) and change work clothes (i.e., next day, many hours later, few hours later, immediately).

We examined the effect of recall on semi-quantitative exposure-intensity scores based on the use of specific PPE items and hygienic behaviour (changing and showering after application). These characteristics represent available data in the current study from a subset of underlying exposure-modifying factors that were used to develop a context-specific pesticide exposure algorithm for applicators in LMICs who use handheld knapsack sprayers (Fuhrimann et al., 2020) (See Supplementary Material for exposure score calculations and individual inputs [PPE, CHANGE, and SHOWER]).

2.3. Data analysis

All data analysis was performed using Stata v16.

In the current paper, we compared recalled information in 2019 to interview responses in 2017. We assessed the recall of crops by determining the percentage who correctly identified their three major crops from 2017 (in any order), as well as the percentage who could identify any of their top three crops; we did not exclude farmers who worked with fewer than 3 crops. We calculated correlations to examine if this recall was related to the number of individual crops reported in 2019.

We examined the recall of average hours per day and days per week working in the field by calculating geometric mean ratios (GMRs) of the follow-up compared to baseline estimates (Goedhart et al., 2018). The number of years mixing or applying pesticides was ascertained by subtracting the age at the time of the follow-up survey, or the age when pesticide use ceased (if reported), by the reported age when pesticide use started. Covariates using categories defined by the approximate median values were included to assess any differences in estimation relative to reference groups by demographic and other characteristics, namely sex, age ($<$or $\geq$50 years), number of years working on a farm ($<$or $\geq$20 years), highest level of years of education attained (any primary school or completion of primary school/higher), farm size ($<$or $\geq$2 acres), total number of workers on the farm ($<$or $\geq$3 workers), and monthly household income ($<$or $\geq$27 USD). While no data were missing, workers who reported $<$1 full year of experience mixing or applying synthetic pesticides in 2017 either at baseline ($n = 28$) or follow-up ($n = 24$), were excluded from this specific analysis. We used the test of proportions to compare characteristics in the recall only subgroup with the full cohort.

We assessed the recollection of the use of active ingredients, PPE items, and practice of hygiene habits through sensitivity, specificity, overall agreement, prevalence ratio of follow-up compared to baseline reporting, and area under the curve (AUC). Sensitivity represents the number of correct affirmative responses (true positives/[true positives + false negatives]) and specificity indicates the number of correct negative responses (true negatives/[true negatives + false positives]). Overall agreement shows the percentage of all correct responses (i.e., both affirmative and negative). The prevalence ratio of follow-up compared to baseline reporting suggests whether there is generally higher ($>$1.0) or lower ($<$1.0) reporting at the group level at follow-up. The AUC is an indicator of how well responses can be distinguished and is an overall summary of sensitivity and specificity; AUC of values $<$ 0.7, $\geq$0.7, $\geq$0.8, and $\geq$0.9 represent non-useful, fair, good, and excellent agreement, respectively (Carter et al., 2016). We performed further analysis by comparing the aggregation of active ingredients by the World Health Organization (WHO) hazard levels (World Health Organization, 2020) and type of application (i.e., fungicide, herbicide, insecticide). In addition, we examined recall of the more commonly used individual active ingredients in those who did and did not provide a urine sample for biomarker analysis prior to the follow-up interview and those who were and were not literate (i.e., could not read and write in any language) by comparing the AUC for each sub-group using the 'roccomp' command in Stata (Janssens and Martens, 2020). Also, we assessed the correlation between the use of specific active ingredients in 2019 (as reported by any days of use in 2019) with over-reporting (i.e., incorrectly reporting use in 2017).

We quantified the effect on exposure estimates due to recall discrepancies by comparing the output of Eq. S1 and S2 using the initial and recalled values (see Supplementary Material). We compared the Spearman correlation of the individual inputs (i.e., PPE, CHANGE, SHOWER scores) and median values of Eq. S(1) and Eq. S(2) at both time-points.

2.4. Ethical considerations

The Higher Degrees, Research and Ethics Committee of Makerere University School of Public Health approved this study (reference no. 719).

3. Results

A total of 255 individuals completed the survey in 2019, representing 84% participation of the original PESTROP cohort (Fig. S1). The mean age at follow-up of respondents was 50.4 years (standard deviation [SD] = 13.6), with a mean experience working on agricultural farms of 32.3 years (SD = 15.1). The mean size of farms and total number of workers per farm were 3.8 acres (SD = 3.6) and 4.0 workers (SD = 3.1), respectively. With the exception of a higher proportion of pesticide users, characteristics appeared comparable between those who participated in the second survey with those who did not (Table 1).

Approximately one third of participants could remember the first major crop they were growing at the time of the baseline survey. Although only 13.3% could recollect each of the top three crops they had been growing, 87.1% could remember at least one (Table 2). The median number of crops reported at follow-up was five (range = 1–14), which had little correlation with either the ability to recall any ($r = 0.04$) or all three ($r = -0.02$) major crops.

Agreement between the reported and recalled years working with pesticides was moderate to strongly positively correlated (rho = 0.64), with weaker positive correlations for reported and recalled days per week (rho = 0.31) and hours per day (rho = 0.39) working in the field. The overall GMRs of recalled years (0.94 [95% CI: 0.85–1.05]), days per week (1.01 [95% CI: 0.97–1.05)], and hours per day (1.06 [95% CI: 0.97–1.15]) did not indicate any systematic under or overestimation. There were no strong trends by demographic or farm subgroup in the recalled time spent either working with pesticides or working in the field (Table S2).

There were 205 (80.4%) and 184 (72.2%) respondents, respectively, who reported and recalled the use of any synthetic pesticides. The opposite pattern was observed in the reporting of any individual active ingredient, which was lower at baseline ($n = 183$; 71.8%) than recalled ($n = 218$; 85.5%). All but three of the 14 reportedly used active ingredients suggested some general level of overestimated recall, as evidenced by prevalence ratios of $>$1.0. Sensitivity, which ranged from 0% to 87.6% for active ingredients, was better for the more commonly used active ingredients; the three most reportedly used being glyphosate, cypermethrin, and mancozeb. By contrast, specificity (ranging from 44.8% to 100%) and overall agreement (59.8%–96.0%) tended to be lower for the more common pesticides (Table 3). AUC values were $<$0.7, except for mancozeb, 2,4-D, and dichlorvos. There were no observable differences in recall ability of working with common pesticides between farmers ($n = 85$) who provided a urine sample for biomarker analysis and those who did not, or between farmers who were literate compared to those who were illiterate (Table S3). Recall was similar (overall

Table 1
Descriptive characteristics of the recall only (n = 255) and full PESTROP cohorts (n = 302) at baseline.

Characteristic	Recall only n (%)	Full cohort N (%)	Test of proportions
Age (Range=19–92)			p = 0.314
<50 years	115 (45.1)	155 (51.3)	
≥50 years	140 (54.9)	147 (48.7)	
Sex			p = 0.912
Male	151 (59.2)	177 (58.6)	
Female	104 (40.8)	125 (41.4)	
Experience working on a farm (Range=2–73)			p = 0.963
2–29 years	110 (43.1)	131 (43.4)	
≥30 years	145 (56.9)	171 (56.2)	
Education			p = 0.909
Did not complete primary	85 (33.3)	98 (32.5)	
Completion of primary or higher	170 (66.7)	204 (67.5)	
Use of pesticides			p = 0.024
Yes	205 (80.4)	214 (70.9)	
No	50 (19.6)	84 (27.8)	
Missing	-	4 (1.3)	
Size of farm (Range=<1–20)			p = 0.651
≤2 acres	103 (40.4)	113 (37.4)	
>2 acres	152 (59.6)	189 (62.6)	
Number of workers on farm (Range1-27)			p = 0.647
≤3 workers	129 (50.6)	161 (53.3)	
>3 workers	126 (49.4)	141 (46.7)	
Literate			p = 0.971
Yes	229 (89.8)	271 (89.7)	
No	26 (10.2)	31 (10.3)	
Monthly household income (Range 3–1350)			p = 0.796
<40 USD	122 (47.8)	138 (46.3)	
≥40 USD	129 (50.6)	155 (52.0)	
Missing	4 (1.6)	5 (1.7)	
Provided urine sample			p = 0.497
Yes	85 (33.3)	86 (28.5)	
No	170 (66.7)	216 (71.5)	

Table 2
Recall of working with major crops (n = 255).

Crops at baseline	Agreement at follow-up n (%)
1st major crop	87 (34.1)
2nd major crop	44 (17.3)
3rd major crop	42 (16.5)
Any order	
All 3 crops	34 (13.3)
Any 2 crops	133 (51.8)
Any 1 crop	222 (87.1)

agreement = 69.3%–73.5%), but slightly better for fungicides (AUC>0.7), when grouped by types of product and also when grouped by WHO Hazard levels (overall agreement = 75.1%–79.8%) (Table S4). There were very weak to moderate positive correlations between over-reporting an active ingredient and its use in 2019 (Table S5).

The majority of the farmers only used basic PPE to cover their upper-body, legs, and feet. The three most common PPE items reported at baseline were gumboots (79.2%), long pants (72.9%), and long-sleeve shirts (61.6%), which were more reliably recalled (AUC>0.7). A small percentage of farmers reported using (any) protection for the eyes (n = 7; 2.8%), mouth (n = 21; 8.2%), or hands (n = 28; 11.0%), with specificity rates over 90% (Table S6 and Fig. 1). Regarding hygiene habits, less than half could correctly recall bathing or changing clothes immediately following pesticide use, while most could recollect whether they washed their own clothes (Table 4).

Spearman correlations were moderate for PPE scores (rho = 0.49), but weak for CHANGE (rho = 0.27) and SHOWER (rho = 0.17) scores. Median PPE scores (Eq. S(1)) at baseline and recall were each 0.73 (Interquartile range [IQR] = 0.64–0.91). The median recalled PPE-Hygiene Score (Eq. S(2)) was slightly higher (0.52; IQR = 0.40–0.64) compared to baseline (0.47; IQR = 0.35–0.59), with a weak correlation (rho = 0.31).

4. Discussion

We studied Uganda's smallholder farmers' ability to recall their previously reported use and pesticide exposure determinants over a two-year period. In general, we found better agreement in the recall of years compared to hours per day or days per week, with no consistent over or under reporting in this regard. We found instances of better recall for the use of common active ingredients and PPE items, as well as washing clothes. However, there was poor recall of specific crops, and we observed overall trends where more individuals reported the use of active ingredients, and fewer reported the use of PPE items, two years later. We are not aware of any other studies examining recall of pesticide applicators in LMICs; therefore, we discuss our results as they relate to the available research, including in higher income settings.

4.1. Major crops

Difficulty in recall of crop details may be relevant for a setting with two or more cropping seasons, such as in Uganda, during which activities could vary across the variety of up to 14 crops these smallholder farmers grew (Wollburg et al., 2020). Recall of specific crops did not appear to be influenced by the number of crops with which one worked; recall accuracy might be adversely affected from changing crops rather than the total number. Unfortunately, we did not have crop details for intervening years and we are not aware of other studies examining the

Table 3
Recall of the use of specific active ingredients.

Active Ingredient	Baseline Prevalence n (%)[a]	Recalled Prevalence n (%)[a]	Prevalence Ratio	Sensitivity (%)	Specificity (%)	Overall Agreement (%)	AUC
Glyphosate	145 (58.0)	185 (74.0)	1.28	87.6	44.8	69.6	0.66
Cypermethrin	110 (44.0)	128 (51.2)	1.16	71.8	65.0	68.0	0.68
Mancozeb	102 (40.5)	136 (54.0)	1.33	81.4	64.7	71.4	0.73
Profenofos	89 (35.7)	85 (34.1)	0.96	41.6	70.0	59.8	0.56
2,4-D	88 (35.3)	117 (47.0)	1.33	76.1	68.9	71.5	0.73
Dichlorvos	30 (12.1)	55 (22.1)	1.83	63.3	83.6	81.1	0.73
Dimethoate	26 (10.4)	36 (14.5)	1.38	38.5	88.3	83.1	0.63
Lambda-Cyhalothrin	24 (9.6)	36 (14.4)	1.50	41.7	88.5	84.0	0.65
Chlorpyrifos	17 (6.8)	27 (10.8)	1.59	29.4	90.5	86.4	0.60
Carbaryl	11 (4.4)	1 (0.4)	0.09	9.1	100	96.0	0.55
Permethrin	9 (3.6)	10 (4.0)	1.11	0	95.8	92.4	0.50
Carbofuran	8 (3.2)	6 (2.4)	0.75	12.5	97.9	95.2	0.55
Diazinon	8 (3.2)	31 (12.5)	3.88	12.5	87.6	85.1	0.50
Paraquat	7 (2.8)	27 (10.8)	3.86	42.9	90.1	88.8	0.66

[a] Excluding 'Not applicable' and 'don't know' responses.

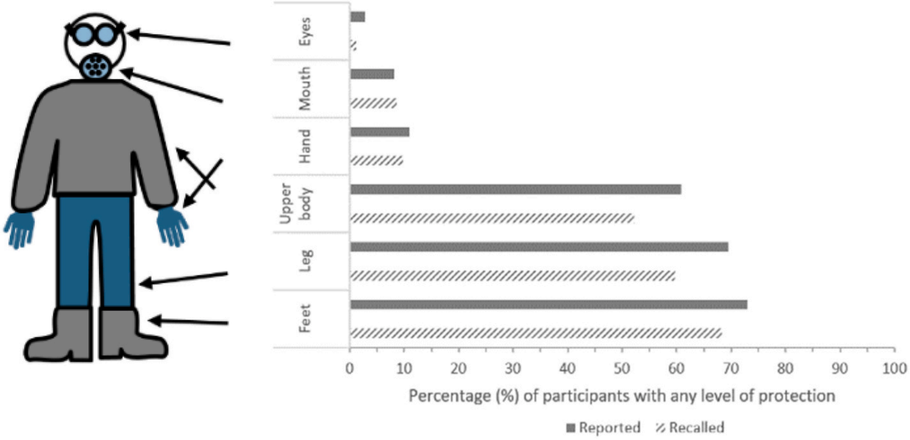

Fig. 1. The number of individuals reporting (in 2017) and recalling (in 2019) any level of protection for a given body part, based on PPE use.

Table 4
Recall of bathing and washing clothes after applying pesticides.

Behaviour	Baseline Prevalence n (%)[a]	Recalled Prevalence n (%)[a]	Prevalence Ratio	Sensitivity (%)	Specificity (%)	Overall Agreement (%)	AUC
Bathing immediately	90 (39.3)	73 (31.9)	0.81	40.0	73.4	60.3	0.57
Changing clothes immediately	92 (40.2)	80 (34.9)	0.87	47.8	73.7	63.3	0.61
Washing own clothes	127 (55.5)	130 (56.8)	1.02	78.7	70.6	75.1	0.75

[a] Excluding 'Not applicable' and 'don't know' responses.

recall of crops in similar settings. The poor recall of crops in this low-income smallholder farmer contexts does not support the use of crop exposure matrices (e.g., London and Myers, 1998; Miligi et al., 1993) when studying smallholders growing a great variety of crops, to infer contact with specific active ingredients.

4.2. Frequency

Similar to previous research in the USA and South Korea, we found better agreement in the estimated years, compared to days per week (Blair et al., 2002) or hours per day (Lee et al., 2010). A longer unit of recall for pesticide use, such as years, may be easier to remember as it would typically involve a static start date compared to the frequency of application or other work practices that might be more dynamic and change between agriculture seasons within a year or from year to year (Fadnes et al., 2009). The difficulty to recollect such practices also may be compounded by a general lack of record keeping or documentation by smallholder farmers in Uganda (Nanyunja et al., 2015). Nevertheless, if the exposure of interest is subject to change from year to year, shorter recall may be more relevant for epidemiology studies. The period of recall may be assisted by the salience of events (Kjellsson et al., 2014), which, for smallholder farmers, may include the relatively infrequent purchase of pesticides in the course of a year (Ngowi et al., 2007). In general, with the exception of the number of workers, we did not observe any differences in recalled duration by demographic or farm features.

4.3. Use of active ingredients

Previous research on recall ability of pesticide use has generally found better agreement for general questions, such as ever/never use of pesticides (Blair et al., 2002; Lee et al., 2010) or broad categories (Engel et al., 2001), compared to more detailed questions about the use of specific products or individual active ingredients. The observed sensitivity for insecticides, herbicides, and fungicides in the present study (79% or higher) is comparable to that identified in orchard workers in the USA (Engel et al., 2001). Contrary to that study, however, sensitivity in the current survey was also acceptable for individual active ingredients, (so long as it was used by >10% of participants at baseline). A potential explanation for this disparity could be the much longer time interval between the two interviews in (Lee et al., 2010) (>20 years) compared to our analysis (2 years).

While one of the earlier studies found little differential reporting of pesticides, except for some lower reporting of specific active ingredients (i.e., malathion, carbaryl, and dichlorodiphenyltrichloroethane) (Blair et al., 2002), another study found over reporting of herbicides and fungicides (Engel et al., 2001); the latter trend, which is more consistent with our results, might have been influenced by the expanded use of these products during the study period. Indeed, we found positive correlations between over-reporting and use of specific active ingredients at the time of follow-up. We also observed a non-statistically significant increase in the percentage who applied pesticides at the time of follow-up compared to baseline (75.3% vs 71.8%), based on reported annual application practices of individual active ingredients (data not shown). Additional involvement in the study, such as providing a urine sample, might have prompted more awareness of pesticide use, though we did not observe any such differences in recall ability of active ingredients. The absence of literacy skills might make it more difficult to be aware of the use of specific active ingredients, yet, again, we did not detect any differences. Another study of smallholder farmers found most (70%) never read pesticide labels (Mengistie et al., 2017); in these settings, pesticides may be repackaged and sold at lower prices, so specific active ingredients may not be clear (Staudacher et al., 2021). Ultimately, the smaller sample sizes for comparison groups would only have detected larger differences in recall between these subgroups.

4.4. PPE and other exposure determinants

The most common form of PPE worn (gumboots) was similar to that identified in a study of farmers in Tanzania (Lekei et al., 2014). The high percentages of overall agreement in responses observed in the current study is in part due to the low reporting of most items, as observed in other studies of farmers in Uganda (e.g., 12% wore gloves) (Oesterlund et al., 2014). The lack of a range of PPE items may be due to lower awareness of the importance of PPE, higher costs, or discomfort in hot and humid conditions (Lekei et al., 2014). For those not wearing the listed PPE items, typical work attire for this tropical setting often involves barefoot or sandals, short trousers, and a short-sleeved t-shirt. Sensitivity was lower (<50%) for washing and changing clothes immediately following the application of pesticides, with around 40% of participants reporting at baseline; these rates are much lower than those reported by pesticide applicators in Italy (>80%) (Riccò et al., 2018). Based on the low reported prevalence of some of these items, it does not appear subjects over-reported socially desirable behaviours (Moore and Rutherfurd, 2020). Information on the use of PPE should be provided via the agro input dealers and label information on the bottle. However, a recent mystery shopping survey suggested this information was unfortunately not consistently disseminated (Staudacher et al., 2021). Training is also organized, mostly by NGOs, though only reaching a small fraction of the farmers and with limited impact (Clausen et al., 2017).

4.5. Exposure algorithms

We found lower overall agreement with the recall of specific hygiene habits (i.e., bathing immediately, changing clothes immediately, and washing own clothes) compared to PPE use. This differs from recall in UK cohorts, where hygiene habits were recalled at least as well as PPE use (Mueller, Jones, Mohamed, Bennett, Harding, Povey, Basinas, Kromhout, van Tongeren, Fuhrimann, Galea). Due to this trend in the current study, we found better agreement in the PPE scores than the PPE-Hygiene scores when comparing reported and recalled data; the PPE-Hygiene scores based on recalled data suggested inflated exposure levels.

4.6. Strengths/limitations and future research

Our research represents the first study to examine the extent of recall of exposure determinants in pesticide users in a LMIC setting. Our results benefitted from a high response rate (84%), although respondents were more likely to use pesticides; users may be motivated to continue participation in research that is more relevant to their own behaviour. Interviews took place at the same time of the year to minimise any seasonal effects on reporting. We used the baseline self-reported data as a proxy for exposure in the prior year to which we compared recall from the follow-up survey two years later. A potential limitation is the accuracy of self-reporting to represent true exposures. In another component of the IMPRESS project, we will examine biomarkers of short-term exposure to active ingredients, which will help validate self-reported current exposures. While the results and extent of recall bias in the current context are encouraging, further research in other LMIC settings would help identify the most reliable and important exposure determinants for use in epidemiological studies of pesticide applicators. In addition, it would be useful to assess the accuracy of recall over longer periods and to investigate the effectiveness of tools to improve recall, such as better documentation of spraying records and other agricultural practices.

5. Conclusion

We performed the first study to assess recall on the use of pesticides and other exposure determinants in a LMIC context. Reporting practices using longer units of time (i.e., years) appeared to be more reliable than recalled hours per day or days per week, with no apparent systematic bias by different demographic or farm characteristics. In general, we found higher levels of agreement for the recall of PPE items and certain active ingredients, with difficulties remembering specific crop types. While some of these findings provide consistency with those from high-income countries, more research is needed on recall bias in poorly educated agriculture communities in low- and middle-income settings to confirm these results.

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Declaration of competing interest

No conflicts of interest are declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijheh.2021.113911.

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