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Research Article

Evaluating Health Risks, Economic Costs and Gender Impacts of Pesticide Exposure in Cotton Production

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Abstract

The use of substantial amount of pesticides to control pests and disease in cotton production leads to creating an unhealthy working environment for farm workers. Health impacts and costs have different implications for men and women farm workers. The present study explores whether female workers experience higher vulnerability to pesticide residual effects than male farm workers. Cross-sectional data collected from four districts of Punjab, Pakistan were employed to compare the health repercussions, associated costs and determinants of health costs. The health cost function and multiple regression were used to find out the influence of various factors on health cost of male and female workers. Among the prevalent health impacts reported by farm workers commonly include flu/fever, skin irritations, nausea/vomiting and eye irritation. Health problems are more pronounced among pesticide applicators when compared with women workers and non-applicators. An evaluation of earnings per hour associated with pesticide exposure underscores a significant disparity among farm workers. Women cotton pickers earn roughly half of what pesticide applicators earn, and their earnings stand at less than four times those of non-applicators. Determinants of health cost include education, the use of PPE, access to healthcare facilities, duration of pesticide exposure and regional disparities, with a few exceptions. This study offers valuable guidance to policymakers to mitigate the health impacts of pesticide exposure among farm workers.

Keywords: Health impacts, Cost of illness, Gender, Cotton.

Introduction

In developing countries, cotton production is highly labor intensive from sowing to harvesting as farm mechanization is less than the developed countries. Different farm activities are done by specific gender and specification of activities among gender varies across developing countries. This is also true for cotton production. In some countries, application of fertilizers, pesticides and irrigation is the responsibility of men (Abbas et al., 2015) whereas cotton picking is commonly performed by women (Yasin et al., 2021; Yousaf et al., 2023). There are certain farm activities in cotton production where both men and women are involved. Some of such activities are manual weeding and sowing. The larger amounts of pesticides used to control pests and diseases in cotton production causes health problems to farm workers involved throughout the world. The excessive, indiscriminate and unproductive use of pesticide (Bakhsh et al., 2012, 2014) causes an invisible cost to human health (Bhat et al., 2020; Yasin et al., 2021). Overuse of pesticide (Schreinemachers et al., 2020) not only affects cotton production, it also has adverse impacts on environment and human health. Worldwide pesticide consumption is approximately 4.11 million tons and Asia consumes a major portion (52%), followed by America (32%) and the rest of the world (16%) (FAO, 2017). This causes number of deaths each year in the

world. According to WHO (2009), nearly 0.3 million farmers performing various farm activities in cotton fields die annually and 99% deaths occur in developing countries. In Pakistan, 10000 farmers are poisoned annually due to excessive use of pesticides just in cotton growing areas (Khan & Damalas, 2015).

In addition to deaths, farm workers are prone to different health problems from pesticide exposure. Reported health problems in the availablea literature include skin allergies, headache, nausea, fever, general weakness, dizziness, eye irritation, vomiting, stomach pain, etc. (Akter et al., 2018; Bakhsh et al., 2016; Kouser et al., 2019; Mehmood et al., 2021; Yasin et al., 2021). Farm workers performing different crop activities have different level of pesticide exposure. Thus frequency of health problems varies among different farm workers (Ganaie et al., 2022) depending on intensity of pesticide exposure. Pesticide applicators are directly exposed to pesticides. They can also be affected to all phases of pesticide application namely cleaning, mixing, loading, spraying, and associated tools and entry to re-entry to farms (Sapbamrer & Thammachai, 2020) and therefore, they face serious health effects and sometimes death due to acute poisoning (Bondori et al., 2018; Damals & Eleftherohorinos, 2011). Women cotton pickers remain for a long period of time per day in the field during picking season of cotton. During picking, women are vulnerable to different types of pollutants including pesticide residues, dust, ultraviolet radiations, etc. With little use of personal protective equipment, women cotton pickers suffer from different types of health problems. Very little or no use of protective measures among farm workers increases probability of health problems further (Kachaiyaphum et al., 2010; Bakhsh et al., 2017; Afshari et al., 2021). The health hazard problems are directly related to the number of sprays and inversely related to the protective measures (Jensen et al., 2011). On the other hand, non-applicators have relatively little exposure to pesticide and other pollutants because of nature of the work done in cotton production.

All farm workers engaged in cotton production face almost similar health problems including skin rashes, eye irritation, nausea, vomiting, etc. (Saeed et al., 2017; Hayat et al., 2019; Mehmood et al., 2021; Yasin et al., 2021; Yousaf et al., 2023). However, the intensity or frequency of health problems among farm workers is different. Similarly, there can be a difference based on gender (women cotton pickers and other farm workers). These health problems have different health costs. Women cotton pickers are assumed to suffer more from health problems and health cost as they have little access to health facilities and low wages compared to men workers. Thus welfare of women cotton pickers can be at higher risk. Aside from the fact that some studies are available in the literature showing impacts of pesticide exposure on health of farm workers-either pesticide applicators, farmers or cotton pickers, how do these impacts vary among pesticide applicators, cotton pickers and non-pesticide applicators?[1] Is it true that health impacts of women cotton pickers are higher than other farm workers? Whether health costs of cotton pickers are higher than pesticide applicators and non-applicators? Is there a strong evidence supporting the stance that the women cotton pickers are more sufferer than other farm workers because of relatively low wages paid to women cotton pickers? There is a gap in the literature to answer these questions because the nature of work and exposure to pesticide residues are different among women cotton pickers, pesticide applicators and non-applicators. This paper contributes to the literature by answering to the above questions.

The purpose of this research is to give insights into why the intensity and or frequency of health problems are different among women cotton pickers, pesticide applicators and non-applicators in cotton production as well as the resultant health cost and its determinants. The discussion of this research is a crucial concern in the community of risk managers and policymakers for improving working environment for the farm workers especially women workers in cotton production in Pakistan and other developing countries. This paper assesses comparatively health impacts and health costs among the farm workers using cross-sectional data collected from two different cotton growing regions of Pakistani Punjab. Findings of the research provide insights into the burden of health impacts resulting from pesticide exposure among the farm workers and this

[1] Pesticide applicators and non-pesticide applicators are male workers in Pakistan. Cotton picking is commonly done by female workers.

knowledge can help decision-makers to determine where investments in health care should be targeted in order to attaining sustainable development in the rural region of the country.

Our study makes twofold contribution to literature. First, this paper is the first one considering pesticide applicators, non-applicators and women cotton pickers simultaneously. Second, the results of this study provide realistic information on relative sufferings of farm workers (pesticide applicators, non-applicators and women cotton pickers). This study is arranged as follows: section 2 covers data collection and econometric methods used in the study, the section 3 describes the findings of the study, section 4 describes discussion and potential economic causes and section 5 concludes and give policy recommendations.

Material and Methods

Study Site and Population

Cotton is highly concentrated in the province of Punjab, Pakistan. Thus this province is selected for the present study. Out of 1880 thousand hectares in Punjab, divisions namely Bahawalpur (38%), Dera Ghazi Khan (22%) and Multan (31%) are the major contributors in cotton cropped area. Similarly these divisions contributes in cotton production (GOP, 2021). Statistics show that out of total pesticide consumed in Pakistan, insecticides account for 80%, herbicides are used in the range of 10%-12% and fungicides make up 8% to 10 percent (FAO, 2019). The use of the pesticides is increasing with the passage of time in Pakistan. The use of pesticides in 2010 was 73632 metric tons per annum (GOP, 2011) and it increased to 206,730 metric tons in 2017 (GOP, 2017). Among the four provinces of Pakistan, 88.3% of pesticides are sprayed in Punjab. The higher use of pesticide contributes towards higher cost of cotton production in Pakistan. Out of total cropped area treated by plant protection, 62% area comes under cotton (GOP, 2021).

Selection of Farm Workers

Both men and women workers are involved in different cotton production activities. Sowing is predominantly carried out by women workers. Men perform application of fertilizer and irrigation, land preparation, spraying pesticides, etc. whereas cotton picking is the responsibility of women workers with a few exception in cotton growing areas of Pakistan. Further, cotton production involves huge quantities of chemicals including pesticides, fertilizers and weedicides. The use of chemicals makes farm workers vulnerable to pesticides and other chemicals. However, vulnerability to pesticide exposure varies among farm workers depending on nature of crop production activities. Pesticide applicators are directly exposed to pesticides whereas non-applicators carrying out activities such as irrigation, fertilizers, land preparation, etc. are little exposed to pesticides and residues. Women involved in cotton picking face different pollutants, namely pesticide residues, ultraviolet radiations, dust, etc. Thus health impacts can vary among farm workers doing different activities in cotton fields. The present study considers these three types of farm workers to compare health impacts and health cost resulting from pesticide exposure.

Data Collection

The present study covers almost all the geographic cotton growing areas of the Punjab province of Pakistan. The data were collected in 2018- 2019 at the end of cotton picking season from wheat-cotton and mixed cropping zones of the province where cotton production is commonly practiced. A total of 540 farm households were interviewed to collect data from different villages of four districts (Toba Tek Singh, Layyah, Khanewal and Vehari) of Punjab. Vehari and Khanewal were taken from cotton-wheat cropping zone whereas Toba Tek Singh and Layyah were taken from the mixed cropping zone. From Vehari district, two tehsils namely Mailsi and Vehari were selected on random basis. Similarly, two tehsils (Khanewal and Jahanian) of Khanewal district were chosen. From Layyah district, Kror Lal Esan and Layyah tehsils were selected randomly. Gojra and Toba Tek Sing tehsils were selected randomly from Toba Tek Singh district. Five rural union councils were chosen randomly for the selection of villages from each selected tehsil. Two villages from each union council were selected at random from each union council. From each village 9 farm households were selected on random basis. From the selected farm households, data was collected from

farmer, pesticide applicator, non-applicators and woman cotton picker. In some houses, data was collected by two female pickers where it was possible. If the farmer was also involved in agricultural labor and or pesticide application, information on both aspects was gathered. Otherwise separate individuals from the selected households were considered who were involved in crop management practices and pesticide application. A total of 530 women cotton pickers were selected from the selected districts. Pesticide applicators and non-applicators were 580 and 358 respondents respectively. Thus the study used data of 1468 farm workers including men and women.

A well-designed questionnaire was developed and pretested before collecting information. Both direct and indirect cost of cotton pickers, pesticide applicators and non-applicators were taken along with socioeconomic characteristics and health impacts relating to pesticide exposure. Direct cost included doctor fee, hospitalization expenses, medicine cost, PPE expenses and indirect cost included travel cost, dietary expenses and productivity loss. Data collection team was designed with support of local organizations. Since literacy rate was very low among farmers and farm workers, questionnaires were filled by data collection team while translating questionnaire in the local language. Data collection team included those students who were familiar with farm practices relating to cotton production and the terms used in the local areas. The students from COMSATS University Islamabad, Vehari Campus and Institute of Agricultural and Resource Economics, University of Agriculture, Faisalabad were involved in data collection. The research team was rigorously trained before starting data collection.

The purpose of the study was explained to the respondents and the respondents were ensured confidentiality of the information. Questionnaire of the study was approved by Ethical Committee for Scientific Research, COMSATS University Islamabad, Vehari campus vide notification CUI-VHR/18-5/ECSR.

Empirical Analysis

Farm workers working in cotton fields experience a decline in welfare due to health cost as a result of exposure to pesticide residues. Health production functions are used to explain health cost function. Welfare of farm workers declines due to two reasons. First, the effected workers face productivity loss when they experience health problems. Second, health problems cause financial burden on the workers in the form of medical expenditures. Thus cost of illness comprises of productivity loss and medical expenditures during the treatment. Cost of using personal protective equipment (PPE) also constitutes cost of illness. In the present study, only those farmworkers were considered who were involved in farming activities continuously. Health cost of farm workers was estimated during cotton growing season. Cost items include doctor fee, costs on hospitalization if any, laboratory fee and medication, travel cost to and from medical facilities, opportunity cost of time spent in traveling, dietary expenses during illness, cost of personal protective equipment and value of productivity loss. Usually one or two family members accompany the patient during the visit to medical facility. Also one family member spares time to care the patient. Value of productivity loss of the accompanied person is also included in heath cost.

Socioeconomic characteristics of the respondents, exposure to pesticide residues, type of farm practices, institutional factors, regional differences and personal protective equipment contribute a change in health cost of farm workers. Since, type of work done by pesticide applicators, non-applicators and women cotton pickers is different from each other, a separate multiple regression is employed to see the effects of various factors on health cost. Socioeconomic characteristics of farm workers include age, education (dummy variables for primary, middle, matriculation and above), experience and earnings per season. Institutional factor namely distances from medical facility is taken as proxy of access to health services. We took distance of rural health facility from farm house in walking minutes. Personal protective equipment employed by farm workers include boots, handkerchief, glasses and mask. Duration of work in cotton production per season is taken as a proxy to pesticide exposure. Regional differences are taken into account using dummy variables of the districts.

Results and Discussion

Descriptive Statistics of the Study

Socioeconomic characteristics of the farm workers are given in Table 1. On the average, all three types of farm workers namely women cotton pickers, pesticide applicators and non-applicators are from the same age bracket i.e. 31-36 years. Illiteracy is higher among cotton pickers than pesticide applicators and non-applicators. Only 17% women have primary education whereas non-applicators and pesticide applicators having primary education are 53% and 15% respectively. Percentage of matriculation and above is higher among pesticide applicators. Experience in the respective farm activity is higher for pesticide applicators whereas women cotton pickers and non-applicators have almost the same experience in the study area. Earnings per season of women cotton pickers is approximately half of the earnings of non-applicators. Almost the same earning of women cotton pickers and pesticide applicators is due to the fact that pesticide applicators are involved in spraying for a few weeks during cotton production and women picking season extends to approximately three months. Health facilities in rural settings are usually located at far distance from the farm houses and farm workers have to travel to health facility in the case of medical urgency. Work duration in cotton fields decides pesticide exposure among different farm workers. Women cotton pickers spend 44.42 hours per season in cotton picking compared to 28.15 and 17.27 hours by pesticide applicators and non-applicators respectively.

Table 1. Socioeconomic characteristics of the respondents.

	Women pickers		Pesticides Applicators		Non-applicators	
Description	Mean	Std. dev	Mean	Std. dev	Mean	Std. dev
Age (years)	34.60	46.37	36.89	10.51	31.26	10.35
Education						
Primary	0.17	0.02	0.15	0.01	0.53	0.49
Middle	0.12	0.01	0.15	0.01	0.16	0.37
Matric and above	0.14	0.01	0.45	0.02	0.13	0.31
Illiterate	0.57	0.02	0.25	0.01	0.18	0.31
Experience (years)	11.38	0.34	17.14	0.41	10.38	7.91
Average earnings (Rs/season)	14809.43	2334.92	15663.79	5565.73	24690.72	3645.30
Access to health facility (km)	72.10	1.63	78.62	36.07	78.91	1.49
Pesticide exposure (hours/season)	44.42	23.57	28.15	19.83	17.27	8.57

Personal Protective Equipment

Personal protective equipment are considered important personal protective equipment in reducing pesticide exposure among farm workers. The type and quantity of PPE vary among farm workers depending on the nature of work. We find that non-pesticide applicators don't use any PPE during different types of farm activities in cotton crop. Those tasks include application of fertilizers and irrigation, weeding, etc. Further, such farm workers are relatively less exposed to pesticides during performing these tasks. Spraying and cotton picking are the most important farm activities in cotton production involving relatively higher level of pesticide exposure. Women cotton pickers and pesticide applicators are found employing different types of PPE. These measures include handkerchief, glasses, boots, gloves and masks. Among these measures, handkerchief is found commonly used among women cotton pickers (73%) and pesticide applicators (54%). The second most important measure is boots reported by women cotton pickers (15%) and pesticide applicators (21%). Percentage of glasses and gloves used by the pesticide applicators is higher than women

cotton pickers. Masks are used by higher percentage of cotton pickers (Figure 1).

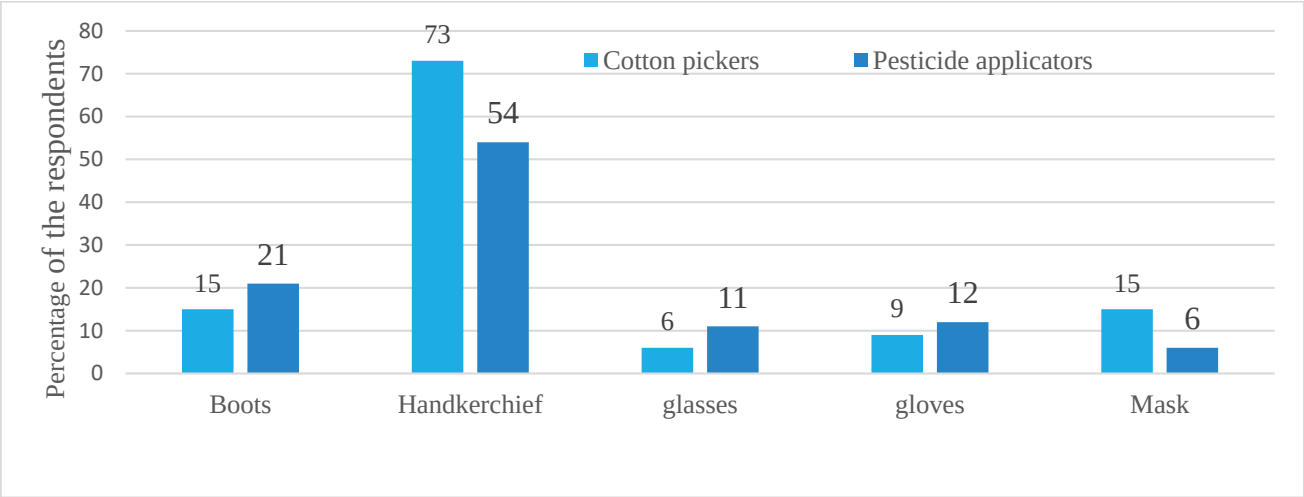

Figure 1. The use of PPE by the farm workers

Pesticide Exposure and the Resultant Health Effects

Table 2 shows different health impacts of pesticide exposure among farm workers. Since the pesticide applicators are directly involved in pesticide application, the higher exposure causes more health problems among such workers compared to non-applicators and women pickers. Flue/fever and skin infection are highly reported health effects resulting from pesticide exposure among all three types of farm workers. The percentage of flue/fever is higher among pesticide applicators followed by non-applicators and women cotton pickers in descending order. Pesticide applicators reporting skin infection are 27% and this percentage is 9.6% for women pickers and 8% for non-applicators. Nausea/vomiting is other notable health effect of pesticide exposure among farm workers. This health problem is higher among the pesticide applicators than women pickers and non-applicators. Percentage of farm workers reporting vomiting/nausea is less among non-applicators than women pickers. Cough, dryness of throat, dizziness, eye irritation, and sleeplessness are some of other health impacts of pesticide exposure among farm workers.

Table 2. Health impacts of pesticide exposure on farmworkers.

Description	Women pickers	Pesticides Applicators	Non-applicators
	Frequency (%)	Frequency (%)	Frequency (%)
Flue/fever	62 (11.7)	137 (24.0)	119 (20.0)
Skin infection	51 (9.6)	157 (27.0)	41 (8.0)
Cough	19 (3.6)	29 (5.0)	29 (5.0)
Dryness of throat	14 (2.6)	19 (3.3)	13 (2.0)
Dizziness	21 (3.9)	34 (6.0)	31 (5.0)
Eye irritation	10 (1.9)	19 (3.0)	7 (1.2)
Nausea/vomiting	23 (4.3)	61 (10.0)	39 (7.0)
Headache	8 (1.5)	24 (4.0)	9 (1.5)
Asthma attack	1 (0.2)	14 (2.0)	3 (0.5)
Shortness of breathing	3 (0.6)	11 (1.8)	5 (0.8)
Sleepiness	4 (0.8)	18 (3.1)	10 (1.7)

Health Cost of Farm Workers

The average health cost of farm workers is provided in Table 3. Health cost includes both direct and indirect cost resulting from different health impacts during and after performing different farm activities in cotton production. On average, non-pesticide applicators have less health cost by 71.18% and 31.61% from pesticide applicators and women cotton pickers respectively. Mean health cost of women cotton pickers is Rs937.63 compared to pesticides applicators (Rs1219.60).[2] Since, pesticide applicators are directly exposed to pesticide, they face more health problems. Expenditures on medicine are higher for pesticide applicators followed by women cotton pickers and non-applicators.

Productivity loss occurs when a farm worker is not able to perform farm activities due to illness resulting from pesticide exposure. Thus productivity loss includes lost work days of farm worker and accompanying person caring the sick person. Pesticide applicators suffer from higher productivity loss (Rs851.56) than women cotton pickers (Rs588.30) and non-applicators (Rs495.90). Women cotton pickers come across a higher productivity loss considering the wage rate in the rural market where women receive half of the wages of men farm workers. On the other side, pesticide applicators receive higher wages because of risk associated with pesticide application.

As health facilities in rural areas are located at far distance, so farm workers have to travel to those facilities resulting in travelling cost and it ranges from Rs28.66 to Rs48.64. Traveling expenses per season include those expenses incurred in visiting doctor and or hospital by a sick person along with accompanying person, if any. Women cotton pickers are found spending higher amount (Rs102.23) on PPE than pesticide applicators (Rs4.51). After suffering from pesticide exposures, farm workers have to take specific diets during the illness time period. Dietary expenses per season also include those expenses when a sick person and or accompanying person bear during doctor and or hospital visitation. We find that dietary expenses are higher for pesticide applicators followed by women cotton pickers and non-pesticide applicators in descending order.

Table 3. Health cost of farm workers.

Components of Health Cost	Women pickers		Pesticide applicators		Non-applicators	
	Mean	S.D.	Mean	S.D	Mean	S.D
Doctor examination fee	23.00	35.31	25.52	98.37	1.90	25.88
Hospital expenses	0.38	8.68	1.21	22.35	-	-
Medicine	115.87	132.39	177.68	169.70	118.76	148.22
Productivity loss	588.30	729.93	851.56	814.09	495.90	676.93
Travelling expenses	32.02	41.72	48.64	43.68	28.66	38.82
Dietary expenses	75.83	90.19	110.44	101.32	66.72	82.52
PPE	102.23	95.35	4.51	8.22	-	-
Total health cost	937.63	652.92	1219.56	653.56	712.45	351.09

Determinants of Health Cost

We considered the short-term health impacts of pesticide exposure on farm workers. Results of multiple regression for each type of farm worker are reported in Table 4. There are two types of factors affecting health cost of farm workers. Some factors cause a decline in health cost and others are positively related with health cost. Positively affecting health cost of farm workers include age, experience, exposure to pesticide, income and access to health facility. Negatively related factors with health cost of farm workers are education and PPE. Regional differences have mixed effects. Socioeconomic characteristics are significantly related with health cost

[2] US$=PakRs157

with a few exceptions. Age of the farm worker is significantly and positively related with health cost, except pesticide applicators. Income (earnings per season) of all three farm workers is significant and positive with health cost. Education with the level of matriculation and above is found negatively associated with health cost of pesticide applicators, non-applicators and women cotton pickers. Middle level education of women cotton pickers is found declining health cost and it is non-significant for other two farm workers. Although positively related with health cost, access to health facility is significant and positive for pesticide applicators. An increasing exposure to pesticide (working hours) causes an increase in health cost of pesticide applicators and women cotton pickers and it is non-significant for non-applicators. The use of PPE namely handkerchief decreases health cost of women cotton pickers and pesticide applicators. Coefficient of this variable is negative and statistically significant. Coefficient of using boots as PPE is negative and significant for pesticide applicators only. Non-applicators are not found using any specific precautionary measure during farm activities namely fertilizer application, irrigation, land preparation, etc. Regional differences also matter causing a change in health cost of farm workers. Health cost of women cotton pickers from Vehari and Khanewal districts is higher from Tob Tek Singh district and it is less for pesticide applicators of Vehari, Khanewal and Laayah districts.

Table 4. Estimates of multiple regression-determinants of health cost.

Variables	Women pickers	Pesticide applicators	Non-applicators
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Socioeconomic characteristics			
Age	1.68*** (0.15)	0.13 (0.30)	0.19* (0.09)
Farming experience	0.45 (0.11)***	0.83 (0.40)**	0.12 (0.23)
Income	0.04 (0.00)***	0.32 (0.11)***	0.35 (0.07)***
Education			
Primary	0.12 (0.06)	0.21 (0.32)	-0.12 (0.08)
Middle	-0.13** (0.09)	0.03 (0.12)	-0.02 (0.08)
Matriculation and above	-0.34* (0.11)	-1.06*** (0.12)	-0.36*** (0.07)
Access to health facility	0.17 (0.07)	0.45*** (0.14)	0.05 (0.05)
Pesticide exposure	0.34*** (0.13)	0.65*** (0.13)	-0.27 (0.18)
PPE			
Boots	-0.09 (0.07)	-0.25** (0.13)	
Handkerchief	-0.52*** (0.05)	-0.47*** (0.11)	
Glasses	-0.04 (0.08)	0.16 (0.15)	
Mask	0.03 (0.06)	0.24 (0.16)	
Regional differences			
Vehari	0.15*** (0.06)	-0.51*** (0.11)	0.06 (0.17)
Khanewal	0.14*** (0.07)	-0.38*** (0.11)	-0.01 (0.16)
Layyah	0.08 (0.05)	-0.28** (0.11)	-0.20 (0.13)
Constant	0.13 (0.27)	2.06*** (0.59)	7.57*** (0.77)
R square	0.49	0.43	0.27
F value	36.69***	35.65***	10.34***
Observation	530	580	358

*** 1% level of significance, ** 5% level of significance, * 10% level of significance.

Discussion

Socioeconomic characteristics of farm workers indicate that women cotton pickers are poor in education and earnings per season with longer hours to pesticide exposure in cotton field compared to pesticide applicators and non-applicators. Higher illiteracy among cotton pickers imply that such farm workers have very little information on pesticide hazardous effects and PPE to be used during pesticide exposure. Among pesticide applicators and non-applicators, many farm workers are illiterate as well, although the percentage is less than women cotton pickers. Low education leading to little awareness of pesticide hazardous effects causes very less use of PPE among farm workers. Afshari et al. (2021), Athukorala et al. (2012), Damalas and Abdollahzadeh (2016) and Migheli (2021) also reported the less use of personal protective equipment by farm workers. Personal protection measures are important in preventing and or reducing exposure to pesticides and residual effects. Closed shoes (boots), handkerchief and mask are commonly reported by the farm workers. The use of handkerchief and masks is higher among women cotton pickers than pesticide applicators. However, the percentage of using PPE is still not at satisfactory level. Literature shows that glasses, gloves and masks are rarely employed by farm workers (Damalas & Hashemi, 2010; Bagheri et al., 2018). Damalas and Koutrobas (2018) and Staudacher et al. (2020) argue that the many farmers don't consider personal protective measures and hygiene conditions during carrying out different agricultural activities, thereby increasing exposure to pesticide. Neglecting health hazards of pesticide exposure happens due to lack of knowledge and or financial constraints (Shammi et al., 2020). This is particularly true for women cotton pickers. Women workers are paid low daily wages than men workers in rural areas of Pakistan. With little financial resources, women workers (cotton pickers) find it difficult to spend on PPE.

No or little use of PPE increases probability of sickness among farm workers. Farm workers can have short-term and long-term health impacts. The present study considers only short-term health impacts of pesticide exposure among farm workers. Health impacts reported by pesticide applicators and women cotton pickers are higher than non-applicators because the later are less exposed to pesticides. Among the reported health symptoms, flue/fever, skin infection and nausea/vomiting are more common health problems in all farm workers considered in the study. Pesticide applicators are more sufferer than women cotton pickers and non-applicators. Pesticide applicators are directly involved in spraying activity, so health impacts are higher among such farm workers. Contrary to non-applicators, women cotton pickers are exposed to pesticide residual effects for a longer period of time compared to non-applicators, percentage of women pickers is higher than non-applicators. Similar health impacts from pesticide exposure are also reported by (Lekei et al., 2014, Bakhsh et al., 2017; Saeed et al., 2017; Zulfiquar et al., 2019). Neglecting health hazards of pesticide exposure due to little knowledge or financial constraints (Bondori et al., 2018; Yousaf et al., 2023) leads to an increase in chances of being sick among farm workers especially pesticide applicators and women cotton pickers. The highly exposed pesticide applicators and women cotton pickers have higher health impacts than less exposed non-applicators (Pinto et al., 2020). Yasin et al. (2021) emphasizes the role of the experience, knowledge and information related to pesticide use in using the protective measures.

Productivity loss is the major contributor of health cost of all farm workers. Farm workers being sick due to pesticide exposure have to face the lost productive day(s) and in return monetary value. The lost working days have adverse effects on consumption of farm workers if they have no or little alternate sources of earnings. It is particularly important for women cotton pickers who have very little opportunity of other sources of earnings. It is evident from the findings that the share of health cost in seasonal earnings of women cotton pickers is 6% and this percentage for pesticide applicators and non-applicators is 7% and approximately 3% respectively. Women cotton pickers are more sufferer, since the lost working days of these workers will not be available compared to pesticide applicators and non-applicators. Pesticide applicators can perform spraying activities in other crops. Similarly, non-applicators find opportunities throughout the year. Cotton picking season remains for some particular days. Figure 2 supports our argument because women cotton pickers have higher number of hours to pesticide exposure compared to pesticide applicators and non-applicators. Thus, earnings per exposure hour of women cotton pickers are far behind of pesticide applicators and non-

applicators. Thus health cost can significantly affect welfare of women cotton pickers.

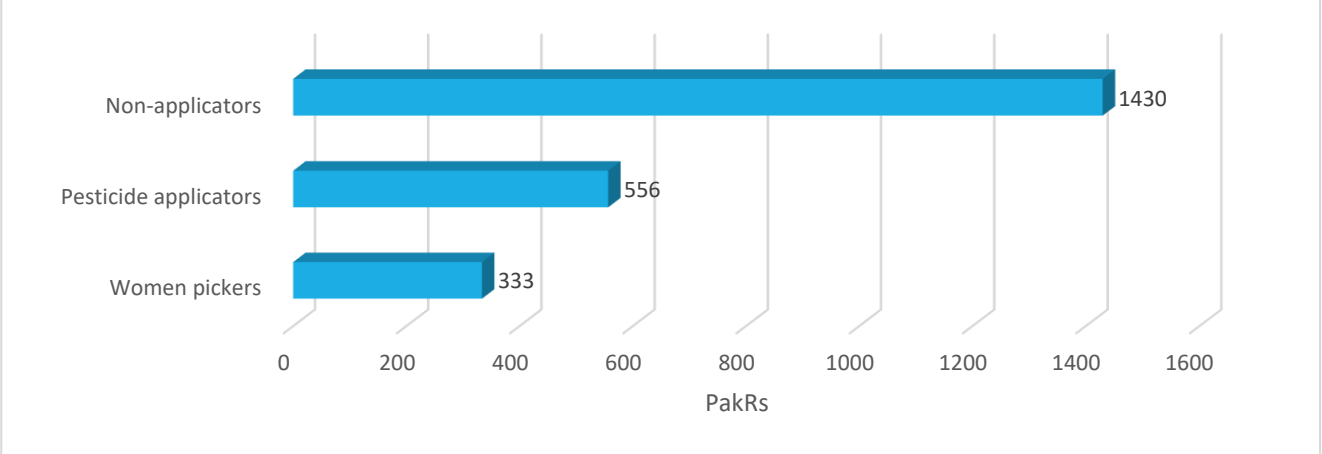

Figure 2. Comparison of earnings per exposure hour of farm workers.

Based on the estimates of health costs, we find that average health cost per woman cotton picker is PakRs937.63 per season and it becomes PakRs0.496 million in the study area (average health cost multiplied by sample size). For pesticide applicators, health cost based on the sample size in the study area is found PakRs0.707 million and PakRs0.255 million is estimated for non-applicators. Overall health cost of farm workers is PakRs1.459 million per season. The season of cotton production usually lasts for six months. These estimates show huge loss to farm workers in the presence of very low wages in agriculture sector. Health impacts of pesticide exposure and resultant health cost adversely hampers general health and quality of life of farm workers (Ahmad et al., 2022). Further, these estimates consider only short-term health impacts of pesticide exposure. Including long-term health impacts and damages to environment and biodiversity will increase costs of pesticide residual effects to many folds in cotton production.

Socioeconomic characteristics such as age, experience and income are found increasing health cost of farm workers with the exception of pesticide applicators where age is statistically non-significant. Positive effect of age and experience imply that with the passage of time, aged farm workers are more prone to health impacts resulting from pesticide exposure. Consequently, such farm workers have to face higher health cost. Income of farm workers increases health cost because the sick farm workers can be able to pay for medical expenses compared to those having low income. Education is important in generating awareness relating to pesticide use among farm workers. Such farm workers with higher level of knowledge in handling polluted environment due to pesticide use have low probability of having health problems, leading to low health cost. Middle and matriculation levels of education among women cotton pickers compared to illiterate women pickers cause a decline in health cost. This happens because educated women are aware of hazardous effects of exposure to pesticide residues in cotton fields. They make PPE to minimize exposure to the residual effects of pesticides and other pollutants in cotton fields. A negative and significant coefficient of matriculation and above level of education of pesticide applicators and non-applicators indicate that these farm workers have less health cost compared to their counterparts.

Working hours in cotton field taken as proxy to duration of exposure to pesticide and residual effects imply that with an increase in exposure time, health cost of women cotton pickers (Yasin et al., 2021) and pesticide applicators increases. However, this coefficient is not significant for non-applicators. Usually farm workers including women cotton pickers and pesticide applicators neglect the hazardous effects of pesticide and residual effects. Lack of knowledge owing to low level of education and availability of PPE in the rural areas are crucial factors for little use of PPE among farm workers. In spite of instructions provided on pesticide products, pesticide applicators-directly exposed to pesticide don't bother to read and act on those instructions. Women cotton pickers, on the other hand, are not aware of those instructions because they don't have access to those instructions at the time of cotton picking. Findings of the study show that among PPE, the use of handkerchief has a significant role in reducing health cost of women cotton pickers and pesticide applicators. The use of boots

(closed shoes) is related negatively with health cost of pesticide applicators. Sapbamrer and Thammachai (2020) find that handkerchief and boots are important factors having impact on health cost of farm workers.

Regional differences are taken to consider variations in the use of advanced technology, development and other factors. Dummy variables of three districts are taken while considering Toba Tek Singh as the base district. Health cost of women cotton pickers in Khanewal and Vehari districts is higher than Toba Tek Singh. Toba Tek Singh is more developed district compared to Khanewal and Vehari. Further, education among women is also higher in this district. Nevertheless, health cost of pesticide applicators in Khanewal, Vehari and Layyah districts is less than Toba Tek Singh. This result implies that pesticide sprays are done with advanced machinery in these districts, being specialized districts of cotton production.

Conclusion and Policy Implications

This study empirically compares health impacts of pesticide exposure and the resultant health cost of farm workers using cross-sectional data from cotton growing region of Pakistani Punjab. Results show that non-applicators are less affected by pesticide exposure than women cotton pickers and pesticide applicators. The use of personal protective equipment namely handkerchief and masks is higher among women cotton pickers than pesticide applicators. In spite of relatively higher use of PPE, health cost of women cotton pickers is higher than non-applicators and this cost is relatively less than pesticide applicators. It means that employing PPE declines health cost of farm workers. This finding is supplemented by the estimates of multiple regression analysis where we find that cotton pickers using handkerchief and boots have lower health cost than non-users of these measures during cotton picking. Education, exposure time to pesticide, age, experience and regional differences are significantly related with health cost. Access to health facility is also important contributor of health cost of farm workers.

Although all farm workers face monetary burden due to pesticide exposure, pesticide applicators and women cotton pickers are at higher risk of losing earnings. Women cotton pickers remain in the cotton fields for long duration of time during picking season compared to pesticide applicators and non-applicators. In the presence of relatively low daily wages received by women cotton pickers, health impacts jeopardize their productivity badly and ultimately the earnings. We estimated earnings of all farm workers based on exposure time to pesticide, the earnings of the women cotton pickers are almost half of pesticide applicators and above four times below of non-applicators. The study provides useful insights for policymakers to devise programs for a reduction in health impacts of pesticide exposures for farm workers. Generating awareness, training and educating farm workers in general and women cotton pickers in particular on health problems linked with pesticides in cotton production can yield the desired outcomes. Lady health workers network exists in the rural areas of Punjab, Pakistan. Strengthening and capacity building of lady health workers can be helpful for women farm workers. These programs should focus on handling pesticides, mixing and the use of personal protective equipment. Widening rural health facilities can be other area of intervention for timely treatment of pesticide poisoning cases and health impacts among farm workers.

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Availability of data and material

Data will be available on the request to corresponding author.

Competing interests

Authors declare that they have no financial and non-financial competing interests.

Ethical statement and formal approval

The study followed well-designed ethics standards and the interviewers explained the purpose of the study to the respondents and ensured them confidentiality of the information. Ethical Committee for Scientific

Research, COMSATS University Islamabad, Vehari Campus confirmed ethics standards followed in the study vide notification CUI-VHR/18-5/ECSR.

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