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A systematic review of employment outcomes from youth skills training programmes in agriculture in low- and middle-income countries

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Engagement of youth in agriculture in low- and middle-income countries may offer opportunities to curb underemployment, urban migration, disillusionment of youth and social unrest, as well as to lift individuals and communities from poverty and hunger. Lack of education or skills training has been cited as a challenge to engage youth in the sector. Here we systematically interrogate the literature for the evaluation of skills training programmes for youth in low- and middle-income countries. Sixteen studies—nine quantitative, four qualitative and three mixed methods—from the research and grey literature documented the effects of programmes on outcomes relating to youth engagement, including job creation, income, productivity and entrepreneurship in agriculture. Although we find that skills training programmes report positive effects on our chosen outcomes, like previous systematic reviews we find the topic to chronically lack evaluation. Given the interest that donors and policymakers have in youth engagement in agriculture, our systematic review uncovers a gap in the knowledge of their effectiveness.

Youth in low- and middle-income countries (LMIC) disproportionately experience working poverty. In 2019, about 21% of employed youth in LMIC were living on less than US$2 a day, compared with 16% of the overall working population[1]. In sub-Saharan Africa, nearly 70% of working youth were found to be living in poverty; in South Asia, close to 50% were living in poverty[2]. Issues of youth unemployment and underemployment are linked to greater likelihood of future unemployment, decreased future job satisfaction, lower income and poorer health in adulthood[3]. National consequences include greater costs to support public programmes (such as public work programmes that provide temporary jobs) and indirect costs of lower earnings such as loss of investment in education[4,5]. Furthermore, youth underemployment is linked to disillusionment and the possibility of social unrest[6].

The working-age population in LMIC is predicted to double in the next 35 years[7] and while this presents challenges, many LMIC are currently experiencing a demographic dividend phase where there is a high ratio of working-age population to dependents. This offers unique prospects for economic development with concomitant reductions in poverty and food insecurity. Addressing unemployment and underemployment is, therefore, a major policy priority for LMIC[6], and a key sector for the creation of employment opportunities, especially in Africa and Asia, is agriculture[6,8,9].

Many people in LMIC rely on agriculture for their livelihoods (32% in 2019)[10], either directly, as farmers, or indirectly in sectors that derive their existence from agricultural production[8,9,11]. Agricultural development is estimated to be up to 3.2 times more effective in alleviating poverty in low-income, resource-rich countries than any other sector[12]. Due to the close links between poverty and food insecurity[13–15], agricultural development could also have positive consequences for the alleviation of hunger, particularly for women, as their empowerment in agriculture improves households' food security and nutrition[16–18].

However, there has been a declining trend of youth participation in agriculture since 2000, mainly in favour of the service sector[6,19,20], which precipitates migration from rural to urban areas. Increased educational attainment for rural youth coupled with inability to rent or own land is a driver of urban migration[21]. In addition, the increasing ageing farmer population in rural areas exacerbates the demographic pressure on land at the expense of the youth[22].

A further constraint on youth engagement in agriculture is a lack of education in disciplines related to agriculture or skills training[23–25]. A study among Thailand's youth reported that 71% identified knowledge of farming practices as a pre-requisite to setting up a viable farm[23]. In rural Ethiopia, government initiatives to increase skills and productivity, and introduce improved and modern farming methods have generated interest among youth in joining the sector, and in Indonesia, vocational training was noted as increasing the likelihood of a successful career in agriculture[26]. A study in Zambia on rural youth aspirations, opinions and perceptions on agriculture documented high interest among youth in more productive forms of farming, such as the use of draught animals, electricity and the increased application of fertilizers[24]. Such findings challenge an assumption common in policy proposals that youth are not interested in agriculture[25]. Today, with the development of information and communication technology (ICT), young people have more opportunities to strengthen their skills and access relevant information and are therefore well positioned to understand market dynamics, and institutional and financial systems, enabling them to initiate and capitalize on processes of change in the agricultural

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sector[27,28]. Human capital theory predicts a positive correlation between human capital accumulation and labour productivity. On that basis, skills training can be used to improve agricultural employment outcomes[29]. Where governments and policy interventions support skills training for youth, there is a real possibility for entrepreneurship, a competitive economy and ultimately national growth. But, despite the implementation of skills training interventions, generally via youth employment programmes[30], few specifically target agricultural skills training in LMIC and very little is known about the effectiveness of youth agricultural interventions[30,31].

Here we systematically review skills-based training interventions that aim to increase youth engagement in agricultural employment in LMIC to better inform investment decisions made by donors and policymakers. The interventions include agriculture-related courses, on-the-job training, technical or vocational education and training in agriculture, as well as general skills training including entrepreneurship, financial literacy and life skills for engagement in agriculture. The outcomes of interest we started out with were: employment along an agricultural value chain; employment in agribusiness; engagement in contract farming; development of agricultural entrepreneurship; agricultural business performance (productivity, profit, income, marketing rate); involvement in agricultural extension service provision. After data extraction, the outcomes of interest found in the selected studies are jobs created in the agricultural sector, self-employment and entrepreneurship, provision of and employment in extension services, profit/income/earnings from an agricultural activity or job, farm productivity, and the accessibility of employment opportunities in the sector. These outcomes pertain to the categories of jobs that can be found along the agricultural value chain.

We found among the studies yielded from the systematic literature search that skills training interventions reported employment in agriculture, agribusiness or agriculture-related activities, development of agricultural entrepreneurship, agricultural business performances (productivity, profit, income) and involvement in agricultural extension service provision for young participants. However, we also found a chronic lack of evaluation of the effectiveness of interventions designed to enhance agricultural opportunities and engagement for young people in LMIC, a finding previously shown[31].

Results

Sixteen studies were identified for review based on a priori inclusion and exclusion criteria (Fig. 1) detailed in our Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocol, PRISMA-P (Supplementary Material 1, summarized in Methods and published on Open Science Framework, https://osf.io/bhegq//).

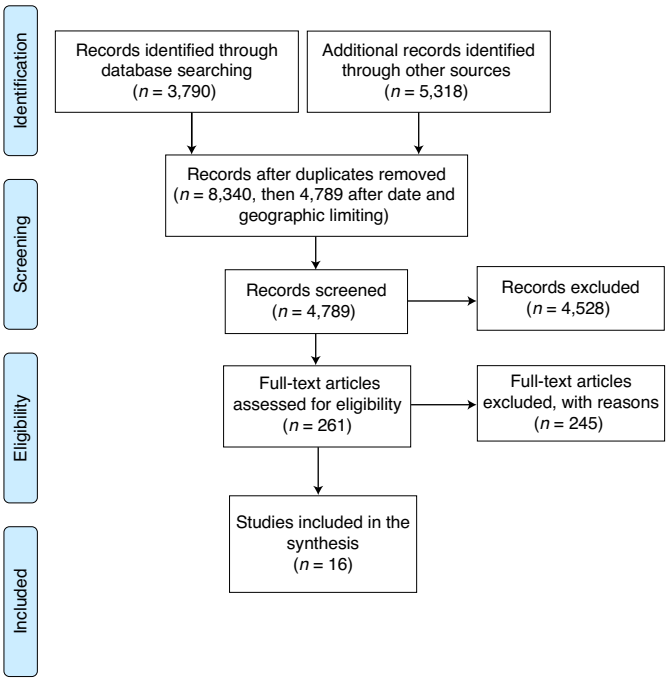

Fig. 1 | Selection of studies for review as per the PRISMA-P protocol. Inclusion criteria were youth as the target population; inclusion of one or more outcome of interest (employment along an agricultural value chain; employment in agribusiness; engagement in contract farming; development of agricultural entrepreneurship; agricultural business performance (productivity, profit, income, marketing rate); involvement in agricultural extension service provision); agriculture sector as field of study; skills training as an intervention; publication in English or French between 1990 and 2019; original research or review of existing research or institutional reports; targets low- and middle-income country or countries as area(s) of study (see list of World Bank country classifications (Supplementary Table 1); a clear and well-accepted methodology (studies were excluded if there was no clear method on sampling, data analysis or discussion of results). Studies meeting the inclusion criteria and targeting mixed group (youth and other demographic groups) were also retained in the search strategy. A double-blind title and abstract screening were performed on 4,789 articles that were uploaded to systematic review software, Covidence, for title and abstract screening. Each article was reviewed by two independent reviewers and discrepancies were resolved by a third independent author within the team. After title and abstract screening, 261 articles remained. From title and abstract screening, 16 articles met a priori inclusion criteria.

Characteristics of selected studies. A data extraction template (Supplementary Table 2) was used to document all information of interest from each of the 16 studies, overviewed in Table 1.

Eleven of the studies were based in Africa[32–42] and five in Asia[43–47]. Twelve of the studies were published in peer-reviewed journals[33–36,39–42,44–47] and the rest originated from the grey literature, including one dissertation[38], one report[37] and two working papers[32,43].

With regard to the study design, nine of the included studies were quantitative[32–37,43–45], four were qualitative[41,42,46,47] and three used mixed non-experimental[38–40] methods. Only one study used randomized control trial (RCT) as a study design method of evaluation[32]. Quasi-experimental impact methods (difference-in-differences (DID) and propensity score matching (PSM)) and quantitative non-experimental methods (statistical and econometric methods) were used in two[33,43] and six[34–37,44,45] studies, respectively. Nine of the included studies relied on survey data[32–37,43–45], one study used data from interviews[47], one study used data from focus groups[42] and the rest of the studies used mixed sources of data[38–40] (Supplementary Table 3).

Table 2 collates information from the selected studies on the basis of types of intervention and participant characteristics. Technical education/training[35,41,42,46] and vocational training[37,40,44,45] constituted half of the interventions (four, each); youth programmes, agriculture-related courses and on-the-job training were identified as interventions in three[33,34,38], two[39,47] and one[36] of the studies, respectively, and the remainder of the studies combined two types of intervention[32,43]. Twelve of the interventions were implemented through public policies[33–35,37–39,41–45,47]; non-governmental organizations (NGOs) and a mix of institutions (public and private) were each identified as implementers in two[32,36] and one[46] of the studies, respectively, and one study reported intervention implemented by an international institution[40].

Nine of the studies solely targeted youth[32–35,37,38,43,45,46], and seven targeted mixed groups of youth and others[36,39–42,44,47]. In fourteen studies, the participants were from all genders. In nine of the studies,

Table 1 | General overview of selected studies

Study design	Authors (year)	Country (state)	Intervention type	Duration of training	Date of data collection	Methods used	Data collection method (sample size)	Population of interest	Key findings	Outcome investigated
RCT (quantitative)	Alfonsi et al. (2017)[32]	Uganda	Vocational training and on-the-job training (NGO)	Four-year programme/ study. Vocational training component lasted six months per participant; on-the-job training component also lasted six months per participant.	2012, 2014, 2015, 2016	Quantitative	Survey (N=1,714 for individuals and N=1,538 for firms)	Youth only (aged from 18 to 25 years)	• Workers in vocational training treatment learn sector-specific skills; full-time workers learn more firm-specific skills. This is associated with higher employment rates for each type of worker including catering sector, but the effect is 50% larger for vocational training (21% versus 14%) and their total earnings increase by more (34% versus 20%).	• Job creation in agriculture • Profit/income/ earning of the farm/ agriculture-related activities
Quasi-experimental impact evaluation method (PSM and DID) (quantitative)	Lachaud et al. (2018)[33]	Zimbabwe	Youth programme (technical and vocational TREE) (public policy)	Four-year programme implementation period in total, and for all beneficiaries	2011, 2014	Quantitative	Survey (N=2,277)	Youth only (aged from 18 to 32 years)	• TREE increased beneficiaries' income by US$787, as well as child and health expenditures by US$236 and US$101, respectively, compared with non-beneficiaries over the 2011–2014 programme implementation period.	• Profit/income/ earning of the farm/ agriculture-related activities
	Chakravarty (2016)[43]	Nepal	Technical and vocational training (skills training and employment placement services) (public policy)	One to three months of training per cohort plus six months of employment placement support. One cohort per year for a total of three cohorts (2010–2012)	Two rounds per cohort (2010, 2011, 2012, 2013)	Quantitative	Survey (N=4,677)	Youth only (aged from 16 to 24 years)	• The skill training intervention positively improved employment outcomes in both farming (poultry technician trade only) and non-farm sector. • The e-skills training interventions also induce women to undertake any income-generating activities including farming comparatively to men.	• Job creation in agriculture • Profit/income/ earning of the farm/ agriculture-related activities

Continued

Table 1 | General overview of selected studies (continued)

Study design	Authors (year)	Country (state)	Intervention type	Duration of training	Date of data collection	Methods used	Data collection method (sample size)	Population of interest	Key findings	Outcome investigated
Correlational (quantitative)	Cheteni (2016)[34]	South Africa	Youth programme (public policy)	Not specified	Not mentioned	Quantitative	Survey (N=140)	Youth only (aged from 15 to 35 years)	• From the logistic regression: when youth programmes are increased by one unit (one programme) youth are eight more times likely to take the offer of participating in agriculture programmes. • A total of 33% of respondents believed that they will be self-employed. • A total of 18% of respondents stated that they will earn money by selling agricultural products, 15% believed that participation will lead to a permanent job, 13% were of the position that agriculture will alleviate poverty in their families. The findings of the survey revealed that youth perceive agriculture as a bad career. • When programmes available are increased by a unit, the odds ratio is 18 times higher and therefore youth are likely to participate in agricultural activities when they are more programmes available for agriculture.	• Engagement/ entrepreneurship in agriculture/contract farming/agribusiness
	Singh et al. (2010)[44]	India	Vocational training on agriculture and allied fields (public policy)	Exact training duration unspecified, but the programme lasted across two calendar years (that is, 1998–1999, 1999–2000, 2000–2001 and 2004–2005)	Unspecified	Quantitative	Survey (N=200)	Mixed group (youth and others)	• The vocational training programmes have resulted in continued adoption of beekeeping and mushroom cultivation enterprises by 20% and 51% trained farmers, respectively. • The continued adopters of beekeeping and mushroom growing had increased their family income by 49% and 24%, respectively.	• Profit/income/ earning of the farm/ agriculture-related activities

Continued

Table 1 | General overview of selected studies (continued)

Study design	Authors (year)	Country (state)	Intervention type	Duration of training	Date of data collection	Methods used	Data collection method (sample size)	Population of interest	Key findings	Outcome investigated
Descriptive (quantitative)	Khosravipour and Soleimanpour (2012)[45]	Iran	Vocational training (agricultural scientific-applied higher education) (public policy)	Not specified	2012	Quantitative	Survey (N=135)	Youth only (graduates of agricultural scientific-applied higher education centres aged on average 28 years with standard deviation of 9.34)	• The graduates entering by free quota (59.6%) in agricultural scientific-applied educations are more than graduates of employment quota (40.4%). • In total, more than half of graduates are employed. However, when considering free quota graduates, about 63.74% were unemployed.	• Job creation in agriculture • Self-employment in agriculture/ agribusiness/ agriculture-related activities
	Gambo Akpoko and Kudi (2007)[35]	Nigeria	Technical training (university-based rural youth agricultural extension outreach programme) (public policy)	Not specified	2005–2006	Quantitative	Survey (N=152)	Youth only (aged from 18 to 30 years)	• The participants had an adoption level of improved practices higher than the non-participants. • Yields of major crops and income of farmers were slightly higher among the participants than the non-participants. •84.2% of beneficiaries achieve yields that exceed one tonne per hectare for maize in Nigeria. • Only 15.8% of the participants obtained yield below one tonne per hectare against 34% among non-participants.	• Productivity of the farm/ agriculture-related activities • Profit/income/ earning of the farm/ agriculture-related activities

Continued

Table 1 | General overview of selected studies (continued)

Study design	Authors (year)	Country (state)	Intervention type	Duration of training	Date of data collection	Methods used	Data collection method (sample size)	Population of interest	Key findings	Outcome investigated
	Hudson et al. (2017)[36]	Uganda, Tanzania, Burkina Faso, Ghana	On-the-job training through radio programmes for farmer (NGO)	Programme intervention lasted a total of 15 months. This seems to have been the case in all sites, for all participants.	2015	Quantitative	Survey (N=1,931)	Mixed group (youth and others)	• The ICT-enhanced participatory radio approach has the potential to enhance food security of smallholder farmers in sub-Saharan Africa (SSA). • The participatory strategies can help to engage audiences, increase knowledge of agricultural improvements and innovations, and contribute to higher levels of adoption than result from listening alone. • The interactivity has the potential to contribute to women's empowerment. • In most cases, significantly more listeners adopted the agricultural practice (growing orange-fleshed potatoes) that was the focus of the participatory radio campaign than non-listeners.	• Self-employment in agriculture/ agribusiness/ agriculture-related activities
	World Bank (2009)[37]	Ghana	Vocational training for youth employment programme (public policy)	Programme launched in 2006. Programme implementation is on a yearly basis (for each cohort).	2006–2007	Quantitative	Survey (N=175,000)	Youth only (aged from 18 to 35 years)	• 92,075 jobs created including 16,383 jobs in agribusiness (17.8%).	• Job creation in agriculture
Case study (qualitative) or case study + descriptive (mixed)	Baah (2014)[38]	Ghana	YIAP (services provided under YIAP include training, extension information, technical support and marketing avenues) (public policy)	Programme introduced in 2009. Lasts for two years.	2014	Mixed methods	Individual interviews and survey (N=44 for both)	Youth only (aged from 15 to 35 years)	• Many of the respondents still pursued farming after exiting the YIAP. About 86.4% of the respondents enroled for the YIAP in 2011 stayed in farming. • The mean income of GH¢758 obtained by beneficiaries was found to be greater than the national mean annual per capita income of GH¢734 (Ghana Living Standard Survey, GLSS 2008).	• Job creation in agriculture • Engagement/ entrepreneurship in agriculture/contract farming/agribusiness • Profit/income/ earning of the farm/ agriculture-related activities

Continued

Table 1 | General overview of selected studies (continued)

Study design	Authors (year)	Country (state)	Intervention type	Duration of training	Date of data collection	Methods used	Data collection method (sample size)	Population of interest	Key findings	Outcome investigated
	Manalo et al. (2014)[46]	Philippines	Technical training on rice farming information (mixed policy)	Eleven-month programme for all beneficiaries, and in total	2012–2013	Qualitative	Focus group discussions (N = not specified), individual interviews (N = 39) and survey (N = 90)	Youth only (students in the national high schools)	• The experiment showed that these students are willing to engage in farming. Also, the paper showed that about 68% of students from Bayanihan National High School and 85% of students from Maria Aurora National High School intended to stay in agriculture as farmers.	• Self-employment in agriculture/ agribusiness/ agriculture-related activities
	Odongo et al. (2017)[39]	Uganda	Agriculture-related course (student–farmer attachment and the SSEP) (public policy)	Implementation period of one year for each programme component (student–farmer attachment and the SSEP), as part of a Bachelor of Agriculture programme. Respondents taken from the first five graduate cohorts (2009–2013) of the programme.	2014	Mixed methods	Survey (N = 60) and individual interviews (N = 20)	Mixed group (youth and others)	• The majority (96%) of graduates obtained their first job within one year of graduation. • The majority (52%) of graduates were engaged in extension work, 13% in business organizations, 14% in research, 1.7% self-employed, 43% in agriculture, 29% in consultancy and 28% in other forms of enterprise. • 42% worked in rural areas, 36% worked in semi-urban areas and 22% worked in urban areas. Most graduates were satisfied. • The majority find the training and preparation adequate for the labour market and the skills relevant to the requirements of their jobs. • 95% of employers find the required skills in graduates.	• Job creation in agriculture • Engagement/ entrepreneurship in agriculture/contract farming/agribusiness • Self-employment in agriculture/ agribusiness/ agriculture-related activities • Provision of agricultural extension service • Job search or employment opportunity in agriculture/ agribusiness

Continued

Table 1 | General overview of selected studies (continued)

Study design	Authors (year)	Country (state)	Intervention type	Duration of training	Date of data collection	Methods used	Data collection method (sample size)	Population of interest	Key findings	Outcome investigated
	Kinyanjui and Noor (2013)[40]	Somalia	Vocational training on livestock value chain (international institution)	Not specified	2011–2012	Mixed methods	Tracer study (survey, $N=16$), individual interviews ($N=$not specified) and focus group discussions ($N=$not specified)	Mixed group (youth and others)	• On average, eight individuals were employed daily in bone-craft production and seven in soap production. • The intervention created a total of 120 direct jobs that were involved in soap and bone-craft production.	• Job creation in agriculture • Profit/income/ earning of the farm/ agriculture-related activities
	Latopa and Rashid (2015)[41]	Nigeria	Technical training in agriculture capacity building centre for the youth (public policy)	The programme was implemented for seven years (2006 to 2013). The duration of the training per cohort was one year.	2015	Qualitative	Individual interviews ($N=30$), and 2 focus group discussions (FGDs), $N=14$	Mixed group (youth and others)	• The programme has contributed to the reduction in the rate of youth unemployment by 70% among trained youth. • The programme helped youth engage in agro-allied businesses and earn income. • The youth training farm helped increase productivity of local farmers.	• Job creation in agriculture • Engagement/ entrepreneurship in agriculture/contract farming/agribusiness • Self-employment in agriculture/ agribusiness/ agriculture-related activities • Productivity of the farm/ agriculture-related activities • Profit/income/ earning of the farm/ agriculture-related activities • Job search or employment opportunity in agriculture/ agribusiness
	Channal et al. (2017)[47]	India	Agriculture-related course on ready food mixes, maize products and mango products (public policy)	Programme started in 2005 and continues until today. Training/cohort duration was two to six days, depending on the training course.	2017	Qualitative	Individual interviews	Mixed group (youth and others; women only)	• Women who received vocational training on ready food mixes started a business and earnt around Rs.5,000 per month by selling these ready food mixes.	• Self-employment in agriculture/ agribusiness/ agriculture-related activities • Profit/income/ earning of the farm/ agriculture-related activities

Continued

Table 1 | General overview of selected studies (continued)

Study design	Authors (year)	Country (state)	Intervention type	Duration of training	Date of data collection	Methods used	Data collection method (sample size)	Population of interest	Key findings	Outcome investigated
	Shoulders et al. (2011)[42]	Egypt	Technical training on agricultural value chain (public policy)	Three-month full-time internships, or six-month part-time internships	2007	Qualitative	5 focus group discussions (FGDs), $N=75$	Mixed group (youth and others)	• Parents noted that their children brought new knowledge back home after their internships. • Students and parents indicated that the students who participated in the internship programme now have disposable income, which they had never had previously. • An increase in collaboration among schools, families and communities emerged as a theme running among each of the focus groups. • Improved relationships between school and families.	• Job creation in agriculture • Engagement/ entrepreneurship in agriculture/contract farming/agribusiness • Profit/income/ earning of the farm/ agriculture-related activities • Job search or employment opportunity in agriculture/ agribusiness

Studies were identified for review as per the PRISMA-P protocol. Data were extracted using a template available as Supplementary Table 2. Studies are described here primarily according to their design: quantitative, qualitative and mixed methods. DID and PSM are also impact evaluation methods that use a treated and control groups approach to assess the effectiveness of an intervention.

participants were a mixed group of those already and not yet engaged in agriculture[32,34,37,39,41–44,46]; in five of the studies, participants were already engaged in agriculture before receiving skills training interventions[35–37,45,47]; there was not enough information to determine whether the participants were already engaged in agriculture in two studies[33,40]. Six of the studies indicated that the participants resided in rural areas[33–36,46,47], while participants located in urban areas and in both rural and urban areas were identified in four[32,38,40,45] and five[37,39,41,43,44] of the studies, respectively; there was not enough information to determine the location of the participants in one[42] study. The population targeted in the studies was both educated and non-educated youth. Among the nine studies[32–35,37,38,43,45,46] that focused exclusively on youth, two targeted youth with a secondary education background[34,46], one[45] targeted youth with a university background and six[32,33,35,37,38,43] of the studies targeted youth with a mixed educational background.

Risk of bias assessment. We evaluated the risk of bias of the included studies based on a previous approach[48]. The domains of risk retained are (1) the sampling technique used for the study, (2) the type of intervention, (3) the choice of the area of study, (4) the population targeted, (5) the method of data collection, (6) the method of data analysis, (7) the measurement of outcome and (8) the statistical significance of the effect. For each domain of risk, the criteria evaluated were defined and rated by their relevance for assessing the effectiveness of the interventions. Supplementary Table 4 summarizes the criteria of each domain of risk and its assessment and rating.

Using this scale, 15% of our included studies are at low risk of bias, 60% at moderate risk of bias and the remaining 25% at serious risk of bias. The outcome of the risk of bias assessment of the included studies in this systematic review is presented in Table 3.

The risk of bias assessment process highlighted differences in focus, methods used and standards of evidence across the included studies. Weaknesses in study design, survey methods and method of evaluation of the impact of the interventions were common in most of the studies (with the exception of the studies ranked at low risk of bias), leading to weak results and limited generalizability.

Effects on youth employment outcomes. The youth employment outcomes of interest to this systematic review are job creation, self-employment, engagement in entrepreneurship, provision of extension services, productivity of the farm/agriculture-related activities, profits/income, and job search or employment opportunity in agriculture-related activities. Here we elaborate on the study design and risk of bias of all studies, and highlight the effects on outcomes of interest for a selection of low and moderate risk studies.

Job creation in agriculture. Eight studies[32,38–43,45] looked at job creation in agriculture as an outcome. Among those studies, three are quantitative studies[32,43,45], two are qualitative studies[41,42] and three are mixed-methods studies[38–40].

In one quantitative study, deemed at low risk of bias (Table 3), 1,700 workers and 1,500 firms were followed over four years to compare the effects of offering workers vocational training and offering firms wage subsidies to train workers on-the-job (firm training) in Uganda[32]. The results showed that both interventions allowed participants to acquire sector-specific skills and firm-specific skills leading to higher employment rates post-training for each type of worker, but the effect was greater for vocational training compared with firm training (21% versus 14% post-training employment rate) and their total earnings rose by more compared with the firm-training intervention (34% versus 20%). The qualitative studies[41,42], although not designed to assess the effectiveness of an intervention, highlighted a link between skills training and employment

Table 2 | Types of intervention and participant characteristics of the selected studies

	Number of studies	Percentage of studies
Type of intervention		
Agriculture-related courses	2	12.5
On-the-job training	1	6.25
Technical education/training	4	25
Vocational training	4	25
Youth programme	3	18.75
Technical + vocational training	1	6.25
Vocational + on-the-job training	1	6.25
Source of intervention		
International institution	1	6.25
Mixed	1	6.25
NGO	2	12.5
Public policy	12	75
Type of participant		
Mixed group (youth + others)	7	43.75
Only youth	9	56.25
Gender of participants		
Female	1	6.25
Mixed	14	87.5
Other	1	6.25
Occupational status of participants		
Participant already engaged in agriculture	5	31.25
Mixed group	9	56.25
Other	2	12.50
Location of participants		
Rural	6	37.5
Urban	4	25
Mixed	5	31.25
Other	1	6.25
Educational background for studies focusing on the youth only		
Secondary	2	22
University	1	11
Mixed group	6	67

outcome. However, both studies were deemed at serious risk of bias. A mixed-methods study[38] on youth programmes in Ghana showed that about 86.4% of young people still pursued maize farming a year after exiting the Youth in Agriculture Programme (YIAP). This public intervention was implemented to address youth unemployment in Ghana with the goal of getting young people to engage in the agricultural sector. The four main components of the programme were crops/block farm, livestock and poultry, fisheries/aquaculture, and agribusiness. The study focuses on evaluating the crops/block farm component. The crops cultivated under the YIAP include maize (seed and grain), sorghum, soybean, tomato and onion. This study is ranked at moderate risk of bias.

Self-employment in agriculture. Six studies[36,39,41,45–47] indicated that skills training interventions resulted in self-employment in agriculture. Out of these studies, two studies are quantitative[36,45], three are qualitative[41,46,47] and one is a mixed-methods study[39].

In one quantitative study[36], self-employment was stimulated by a skills training radio campaign on growing orange-fleshed sweet potatoes in Ghana, Tanzania, Burkina Faso and Uganda. A survey of the local communities where the radio campaign was run found that households that reported hearing the educational radio campaign in Ghana, Tanzania, Burkina Faso and Uganda were 8.9, 2.3, 1.7 and 1.1 times more likely, respectively, to engage in growing orange-fleshed sweet potatoes, than households that did not. This study is deemed at moderate risk of bias.

Engagement/entrepreneurship in agriculture. Five studies[34,38,39,41,42] showed that skills training interventions encourage youth engagement or entrepreneurship in agriculture. Among these studies, one is quantitative[34], two are qualitative[41,42] and two are mixed-methods studies[38,39]. In the quantitative study, a youth programme including agriculture content (training in livestock production, crop production and dairy farming) in South Africa indicated that youth engagement or self-employment in agriculture is eight times higher when agricultural programmes that specifically target the youth are implemented compared with when agricultural programmes are not available. This study is deemed at moderate risk of bias. Regarding the mixed-methods studies, one study[38], deemed at moderate risk of bias with youth programme (YIAP in Ghana) as intervention, showed that after exiting the programme, 86.4% of beneficiaries were still involved in farming within a year. The qualitative studies were deemed at serious risk of bias.

Productivity of the farm/agriculture. Two studies[35,41] found that skills training interventions lead to higher productivity of the farms. One of the studies is quantitative[35] and the other is qualitative[41]. In the quantitative study, estimated to be at moderate risk of bias, the National Agricultural Extension and Research Liaison Services (NAERLS) rural youth extension programmes (RUYEP) helped 84.2% of beneficiaries achieve yields that exceed one tonne per hectare for maize in Nigeria, compared with 66% of non-participants[35]. The qualitative study[41], outlined in Table 1, is deemed at serious risk of bias.

Profit/income earning of the farm. Ten studies[32,33,35,38,40–44,47] looked at profit/income earning of the farm as an outcome. Among those studies, five are quantitative[32,33,35,43,44], three are qualitative[41,42,47] and two[38,40] are mixed-methoda studies. In one of the quantitative studies, the Training for Rural Economic Empowerment (TREE) programme increased beneficiaries' income by US$787 compared with non-beneficiaries over the 2011–2014 programme implementation period[33]. This study is deemed at low risk of bias. Another quantitative study[44], deemed at moderate risk of bias, found that the continued adopters of beekeeping and mushroom growing had increased their family income by 49% and 24%, respectively. The three qualitative studies, not described here but outlined in Table 1, are deemed at serious risk of bias[41,42,47]. The mixed-methods study[40] showed that the creation of a company that recycled livestock by-product (bone crafts and soap production) allowed vulnerable women and youths to earn an additional US$44.6 from bone crafts and US$50.2 from soap production weekly. This study is at moderate risk of bias.

Job search or employment opportunity. Three studies[39,41,42] investigated the effect of skills training on this outcome. One study is a mixed-methods design[39] and two[41,42] are qualitative. All of these studies, not described here but outlined in Table 1, are deemed at serious risk of bias.

Provision of agricultural extension service. One study[39] investigated on the effects of skills interventions on provision of agricultural

Table 3 | Risk of bias assessment

Number	Authors (years)	Sampling	Intervention	Area of study	Population	Method of data collection	Method of data analysis	Outcome	Significance	Total number of stars	Score (%)	Level of risk of bias
1	Alfonsi et al. (2017)[32]	3	1	2	2	4	5	2	2	21	91	Low
2	Lachaud et al. (2018)[33]	3	1	3	2	4	4	2	2	21	91	Low
3	Chakravarty (2016)[43]	3	1	1	2	4	4	1	2	18	78	Low
4	Cheteni (2016)[34]	1	2	2	2	4	3	1	2	17	74	Moderate
5	Singh et al. (2010)[44]	3	1	1	1	4	3	1	2	16	70	Moderate
6	Khosravipour and Soleimanpour (2012)[45]	3	1	2	2	3	2	1	2	16	70	Moderate
7	Gambo Akpoko and Kudi (2007)[35]	2	1	3	2	4	2	0	2	16	70	Moderate
8	Hudson et al. (2017)[36]	3	1	3	1	4	2	0	2	16	70	Moderate
9	World Bank (2009)[37]	1	1	1	2	3	2	1	2	13	57	Moderate
10	Baah (2014)[38]	1	2	2	2	4	2	1	1	15	65	Moderate
11	Manalo et al. (2014)[46]	1	1	3	2	4	2	0	1	14	61	Moderate
12	Odongo et al. (2017)[39]	1	1	1	1	4	2	0	1	11	48	Serious
13	Kinyanjui and Noor (2013)[40]	1	1	2	1	4	2	1	0	12	52	Moderate
14	Latopa and Rashid (2015)[41]	1	1	1	1	2	1	0	1	8	35	Serious
15	Channal et al. (2017)[47]	1	1	3	1	1	1	1	1	10	43	Serious
16	Shoulders et al. (2011)[42]	1	1	0	1	2	1	0	1	7	30	Serious

The evaluation of the included studies bias is based on a previous approach[48]. For example, for the domain of risk relating to the sampling technique, three criteria were identified: random sampling, non-random sampling and a mix of the two types of sampling. The maximum rate a study can obtain in this domain is three stars. If the study used a random sampling technique, it gets three stars; if it uses a mix of the two types of sampling, it gets two stars; and if the sampling technique is not random, it gets one star (see Supplementary Table 4 for details on the criteria used).

extension service and found that the majority of graduates who benefited from student–farmer attachment and/or the Supervised Student Enterprise Project (SSEP) were engaged in extension work. This study, outlined in Table 1, is deemed at serious risk of bias.

Intervention type and engagement in agriculture. *Agriculture-related courses.* Two studies[39,47] used agriculture-related courses as interventions. One of these studies is a mixed-methods study[39] and the other is qualitative[47]. The mixed-methods study investigated several outcomes in agriculture, namely, job creation, entrepreneurship, self-employment, provision of agricultural extension service and job search opportunity, which were found to improve with the skills training interventions. The interventions consisted of introducing innovations in agricultural training curricula (community engagement and agri-enterprise development) at Gulu University in Uganda. The community engagement took the form of a one year (or less) placement of undergraduate students to work with smallholder farmers and farmer groups within a 10 km radius of the university. The agri-enterprise development consisted of having the students design business plans; the best plans were rewarded with start-up capital. The employment rate among the graduates was 84% six months after graduation and increased to 90% after one year; less than 2% of the graduates created their own businesses. The qualitative study[47] investigated two outcomes in agriculture, self-employment and income, which were found to increase after skills training on ready food mixes, maize products and mango products. The two studies are deemed to be at serious risk of bias.

Technical education/training. Four studies[35,41,42,46] used technical education/training as interventions. Only one of these studies is quantitative[35]; the others are qualitative[41,42,46]. The quantitative study[35] investigated productivity and income of the farm, and found both to increase after the intervention. The NAERLS RUYEP objectives

Table 4 | Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Study includes youth as the target population	Study does not include youth as the target population
Study must focus on one of our outcomes of interest	Study does not include one of our outcomes of interest
Study targets agriculture sector as field of study	Study does not include agriculture as target field of study
Study includes skills training as an intervention	Study does not include skills training as intervention
Study published from 1990 to 2019 in English or French	Study not written in English or French and published before 1990
Study reported as original research or review of existing research or institutional reports	Study that is neither original research nor a review of existing research nor reports
Study targets low- and middle-income country or countries as area(s) of study	Study that does not target low- and middle-income countries
Study with a clear and well-accepted methodology	Study does not have a clear or well-accepted methodology

The exclusion criteria are the opposite of the inclusion criteria. Our outcomes of interest are: employment along an agricultural value chain; employment in agribusiness; engagement in contract farming; development of agricultural entrepreneurship; agricultural business performance (productivity, profit, income, marketing rate); involvement in agricultural extension service provision. By well-accepted methodology we mean studies were excluded if there was no clear method on sampling, data analysis or discussion of results. For the list of World Bank country classifications, see Supplementary Table 3. English and French were chosen given the language proficiency of the researchers.

are to provide technical advisory services to boost agricultural production and raise living standards of the youth. The results showed that the intervention allowed 84.2% of beneficiaries to achieve yields that exceed one tonne per hectare for maize in Nigeria, compared with 66% of non-participants. This study is deemed at moderate risk of bias. Among the qualitative studies, one[46] looked at self-employment as an outcome and found a positive association with the intervention. The other two qualitative studies are deemed of serious risk of bias.

Youth programme. Youth programmes are programmes that target youth and train them in either specific skills (agricultural skills, ICT skills and so on) or broad skills (decision-making skills, business skills and so on) to enhance their employability. These have been used as interventions in three studies[33,34,38]. One of these studies is mixed methods[38] and the two others are quantitative[33,34]. The mixed-methods study[38] investigated the following outcomes in agriculture: job creation, engagement and income; a positive association was found between youth programme and both engagement and income. The results showed that about 86.4% of young people still pursued maize farming one year after exiting the programme and the mean income of GH¢758 obtained by beneficiaries was found to be greater than the national mean annual per capita income of GH¢734. Among the two quantitative studies[33,34], one investigated the income of beneficiaries[33] and the other[34] looked at engagement in agriculture; both found a positive effect of the intervention on their outcome. The study that investigated the income of beneficiaries as an outcome revealed that the TREE programme increased beneficiaries' income by US$787 compared with non-beneficiaries over the 2011–2014 programme implementation period[33]. In the other study[34], a youth programme including agriculture content (training in livestock production, crop production and dairy farming) in South Africa indicated that youth engagement or self-employment in agriculture is eight times higher when agricultural programmes that specifically target the youth are implemented compared with when agricultural programmes are not available. Given that all three studies are at moderate or low risk of bias, we can conclude that the findings suggest that youth programmes have the potential to influence youth engagement in agriculture.

On-the-job training. Only one study[36] looked at on-the-job training as an intervention. The outcome investigated is self-employment, on which the intervention had a positive effect. The results showed that households that reported listening to an educational radio campaign in Ghana, Tanzania, Burkina Faso and Uganda were 8.9, 2.3, 1.7 and 1.1 times more likely, respectively, to engage in growing orange-fleshed sweet potatoes, than households that did not. The study was deemed at moderate risk of bias.

Vocational training. Vocational training has been used as an intervention by four studies[37,40,44,45]. Among these studies, three are quantitative[37,44,45] and one is a mixed-methods study[40]. One quantitative study[44] investigated income as an outcome, on which positive effects of the intervention were found in India. The findings indicated that vocational training programmes have resulted in continued adoption of beekeeping and mushroom cultivation enterprises by 20% and 51% of trained farmers, respectively, and increased their family income by 49% and 24%, respectively. The second quantitative study investigated job creation and self-employment as outcomes and found positive links with the training[45]. The results of the study highlighted that vocational training in agriculture in Iran resulted in employment of more than half of graduates. The third quantitative study found a positive effect of the intervention on job creation, the sole outcome it had investigated[37]. The study showed that vocational training for a youth employment programme in Ghana resulted in the creation of 16,383 jobs in agribusiness. All four studies are deemed at moderate risk of bias (Table 3); however, the use of descriptive methods in some of these studies preclude us from concluding that they are effective in improving employment outcomes for youth in the agricultural sector.

Vocational training and technical training. One study[43] investigated the combination of vocational training and technical training as an intervention. The outcomes investigated are job creation and income, on which the intervention had a positive effect. The study indicated that vocational training and technical training in agriculture (poultry technician) resulted in an increase in employment of 34.2% among the 41 beneficiaries who were trained as poultry technicians in Nepal. This study is deemed at low risk of bias, suggesting that combining vocational training and technical training may be a way of improving job prospects and income for youth in the agricultural sector.

Vocational training and on-the-job training. One study[32] investigated the combination of vocational training and on-the-job training as an intervention. The outcomes investigated are job creation and earnings, on which the intervention had a positive effect. The results showed that both interventions allowed participants to acquire sector-specific skills and firm-specific skills, leading to higher employment rates post-training for vocational-trained workers compared with firm-trained workers (21% versus 14% post-training employment rate) and their total earnings rose by more compared with the firm-trained workers (34% versus 20%). This study is deemed at low risk of bias.

Duration of training. Ten studies out of the 16 overviewed in Table 1 presented information on the duration of training. Eight of these have programmes that last one year or less. The remaining studies indicated a training duration between two and five years. This suggests that training programmes predominantly have a relatively short-term duration, which is consistent with many interventions taking the form of technical and vocational education/training.

The popularity of technical and vocational/education training as a model of intervention may be due to the relatively short-term nature of the training, or due to the nature of technical and vocational training, which is well suited for out-of-school youth, which are found in large numbers in LMIC[49].

Discussion

Issues facing youth engagement in agriculture today are relatively well documented, including educational attainment, matrimonial status, gender, household size, parental income and occupation, membership in social organization, access to ICT, land tenure system and access to state-run agricultural youth programmes[50–52]. This present systematic review, which focused solely on interventions to engage youth in agriculture, yielded a limited set of studies—nine quantitative, four qualitative and three mixed-methods studies—so generalizable conclusions are difficult to draw. The risk of bias assessment yielded three studies[32,33,43] deemed at low risk of bias, nine studies[34–38,40,44–46] deemed at moderate risk of bias and four studies deemed at serious of risk bias[39,41,42,47].

The results of our systematic review generally are in line with those found by the systematic review of Kluve et al.[53] on interventions to improve the labour market outcomes of youth. That systematic review of 107 interventions, including skills training, in 31 countries, found small positive effects for promoting entrepreneurship and skills training—especially integrated skills training programmes—but not for employment services and subsidized employment.

Our systematic review also demonstrated that in general, skills interventions seeking to motivate youth's engagement in agriculture do not undergo a thorough evaluation for effectiveness, with hard outcomes related to employment. Our selected studies included case studies and qualitative methods, which are not adequate methods of evaluating impact and effectiveness of interventions. Only one study used an RCT[32]. The two studies relying on a quasi-experimental approach used DID and PSM methods[33,43]. Indeed, the results of the risk of bias assessment indicated the studies relying on RCT and quasi-experimental impact evaluation methods were at low risk of bias. However, these study designs are expensive to conduct. We found that of the studies that evaluate interventions, the majority did not use state-of-the-art impact evaluation methods. This has been corroborated by other studies[30,31], showing a chronic lack of evaluation of interventions that aim to provide agricultural skills to youth.

Training on ICT is an important aspect for attracting and retaining youth in the agricultural sector[46]. ICT offers a method of delivering training to a large number of farmers, which could enhance the performance of the youth already in agriculture and attract new youth to the sector[36]. Radio campaigns have been shown to be effective in spurring adoption and consumption of orange-fleshed potatoes in Ghana, Tanzania, Burkina Faso and Uganda[36]. A study conducted in the Philippines found that ICT training helps motivate secondary school students whose parents are engaged in agriculture to work within the sector, especially when combined with offline activities such as exposure and hands-on experience as well as creative and motivational actitivites[46].

It is important to note that heterogeneity in gender and education are not accounted for in the analysis of the impacts of education on youth participation in agriculture. Our systematic review revealed that most of the included studies failed to address the effectiveness of targeting the population of interest—educated and uneducated youth. Illiteracy and gender heterogeneity were not addressed in the included studies. Indeed, no studies assessed the effects of training interventions on illiterate youth. This calls for investigations to focus on this vulnerable group of society, which represent about 25% of youth in sub-Saharan Africa and 11% in Southern Asia[54]. Failing to account for such variation in the background of the youth participants limits the ability to assess the effectiveness of skills training interventions.

The absence of robust research and lack of effective evaluation of the available data on the effectiveness of agricultural youth employment interventions has notable consequences on potential investment. Ultimately, the commitment of policymakers is necessary to ensure the sustainability and success of interventions to boost youth's engagement in agriculture. It is encouraging that the majority of interventions (12 studies out of 16) studied originated from public policy, compared with three originating from non-public policy programmes (NGOs, international institution) and one from mixed policies (public and non-public policies). However, to provide a compelling basis on which to convince governments and donors to fund future interventions, as well as encourage young people to partake in training, cost-effectiveness analysis and estimates of returns on investment in training programmes is necessary. Indeed, a 2018 stocktaking of the evidence on the effectiveness of youth employment interventions in Africa found that for the agricultural sector in particular, "there is very little literature and virtually no evaluation evidence to inform policymakers about what types of interventions can improve the prospects of young people in the [agricultural] sector"[31]. Our study supports this conclusion. Moreover, to ensure that the skills training provides long-term opportunities for youth, it is crucial to establish a periodic follow-up to assess how trainees are performing after completion of a training programme. This aspect was missing in most of the interventions reviewed in this systematic review, yet it is important to check that the youth who engage in agriculture after receiving skills training are still involved and thrive in their agriculture-related business in the long term.

In summary, there is a need to foster youth skills training programmes and more importantly to evaluate more rigourously these programmes so that knowledge on good practices may be generated and transferred from one developing country to another. Estimates of returns to investment of agricultural skills training programmes are warranted as they could provide governments and donors with the evidence and cost-based analysis to continue and increase support for such programmes. Interventions also need to account for heterogeneity in gender and educational background of the youth to foster sustainability in agricultural value chains, inform inclusive policy design and ultimately contribute to reducing poverty and food insecurity in LMIC.

Methods

This systematic review was prepared following guidelines from Petticrew and Roberts[55]. The approach comprises five steps: identifying the research question; identifying relevant studies; study selection; extracting and charting the data; and collating, summarizing and reporting the results. The protocol for this study was registered on the Open Science Framework before study selection and can be accessed at https://osf.io/bhegq//. The guiding question for this systematic review was: What are the effects of skills training interventions on educated and non-educated youth employment outcomes in agricultural value chains, agribusiness or contract farming in LMIC? The inclusion and exclusion criteria to identify and then select the relevant studies are shown in Table 4.

Risk of bias assessment. Regarding the risk of bias assessment, each study was assessed following the criteria of the eight domains of risk of bias we considered. The maximum score a study can obtain in terms of minimizing all domains of risk of bias is 23 stars, which is 100% of the stars. A study is deemed to be at low risk of bias across all domains if its total score is in the interval 75–100%. If the total score is in the interval 50–75%, the study is said to be at moderate risk of bias across all domains. A study is at serious risk of bias if its score falls within the interval 25–50%. When the total score ranges from 0 to 25%, the study is deemed to be at critical risk of bias across all domains. See Supplementary Table 4 for details on the criteria used.

Search strategy. An exhaustive search strategy was developed and tested in CAB Abstracts to identify all available research pertaining to the effects of skills training interventions on educated and non-educated youth employment outcomes in agriculture in LMIC. Search terms were developed to address variations of the key concepts in the research question: skills training, youth, employment or

engagement, and agriculture. Searches were performed on 9 May 2019 in the following electronic databases: CAB Abstracts (access via OVID); Web of Science Core Collection (access via Web of Science); EconLit (access via ProQuest); Agricola (access via OVID); and Scopus (access via Elsevier). Full search strategies for each database, including grey literature, can be accessed in their entirety at https://osf.io/xv56k/.

A comprehensive search of grey literature sources was also conducted. A list of the resources that were searched can be found at https://osf.io/xv56k/. The grey literature searches were performed using custom web-scraping scripts. The search strings were tested per website before initiating web-scraping. An existing Google Chrome extension was needed to scrape dynamically generated websites.

The results from the databases and the grey literature searches were combined and de-duplicated using a Python script. Duplicates were detected using title, abstract and same year of publication, where year of publication was a match, where title cosine similarity was greater than 85%, and where abstracts cosine similarity was greater than 80% or one of the abstracts (or both) was empty. When duplicates were found, the results from the databases and the grey literature searches were combined and duplicates were removed.

Following de-duplication, each citation was analysed using a machine-learning model. The model added more than 30 new metadata fields, such as identifying populations, geographies, interventions and outcomes of interest. This allowed for accelerated identification of potential articles for exclusion at the title/abstract screening stage.

Study selection and eligibility criteria. Systematic review software, Covidence, was used for both title/abstract and full-text screening decision-making with two independent reviewers evaluating each item. Citations were included in this study if they met all of the inclusion criteria noted above. Studies that did not meet all the inclusion criteria were excluded. Exclusion criteria were the inverse of the inclusion criteria. Each citation that met one of the exclusion criteria at the title, abstract or full-text screening phases were excluded. Studies included in the full-text screening stage were those that met all inclusion criteria and none of the exclusion criteria, or those whose eligibility could not be established during title/abstract screening. Reasons for exclusion were documented at the full-text screening phase.

The retrieval of hundreds of PDFs for full-text screening was done with a combination of automated and manual methods. For the automated method, a Python script was created that would handle the tasks of PDF discovery, download and file renaming using Google Scholar. The script read the bibliographic data from an Excel spreadsheet and then executed a script to retrieve the full-text PDF. If the article is spotted in the search results, the download link is clicked, and the article will be auto-renamed and marked as being downloaded. Manual methods were employed for those items that were not retrieved using the script.

A total of 245 records were identified for full-text screening. This screening process led to the identification of 16 studies that were considered adequate regarding the content and methodological rigour. The PRISMA flow diagram (Fig. 1) shows the steps followed during the screening process and the number of items that resulted after each step.

Data extraction. Data extraction was based on interventions and outcomes established in the research question and exclusion criteria. The data extraction focused on the outcomes of the studies, the methods used to obtain the outcomes, and the validity and reliability of those methods using a data-extraction form. To reduce risk of bias related to the extracted data, two separate researchers extracted data from each included study in the full-text review step. When disagreements occurred between researchers on data extracted from a study, a third researcher was engaged to resolve conflict by extracting data again from the study and the results were compared with those found previously. In total, 31 conflicts were solved among the 261 reviews. The critical appraisal of individual sources of evidence gave an indication of the strength of evidence provided and informed the standards followed for this systematic review.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Code availability

The code used in this study is available upon request.

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Author contributions

W.H.E.M., M.P. and P.Z. developed the research question. J.A.K. and G.C. conducted the literature search. All authors drafted the PRISMA-P protocol for this study. W.H.E.M., M.P., P.Z, C.J.A, D.A.C., J.F., W.S. and S.T. conducted the full-text reviews and drafted the paper, and all authors contributed to the writing.

Competing interests

The authors declare no competing interests.

Additional information

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Software and code

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Data collection

An exhaustive search strategy was developed and tested in CAB Abstracts to identify all available research pertaining to effects of skills training interventions on educated and non-educated youth employment outcomes in agriculture in developing countries. Search terms were developed to address variations of the key concepts in the research question: skill training, youth, employment or engagement, and agriculture. Searches were performed on May 9, 2019 in the following electronic databases: CAB Abstracts (access via OVID); Web of Science Core Collection (access via Web of Science); EconLit (access via ProQuest), Agricola (access via OVID), and Scopus (access via Elsevier). Full search strategies for each database, including grey literature, can be accessed in their entirety at https://osf.io/xv56k/.
The results from the databases and the grey literature searches were combined and de-duplicated using a Python script. Duplicates were detected using title, abstract and same year of publication, where year of publication was a match, where title cosine similarity was greater than 85%, and abstracts cosine similarity greater than 80% or one of abstracts (or both) was empty. When duplicates were found, the citation priority order was Scopus, CAB Abstracts, Web of Science, Agricola, EconLit, and followed by grey literature sources.

Data analysis

Systematic review software, Covidence, was used for both title/abstract and full-text screening decision-making with two independent reviewers evaluating each item. Citations were included in this study if they met all of the inclusion criteria noted above. Studies that did not meet all of the aforementioned inclusion criteria were excluded. Exclusion criteria were the inverse of the inclusion criteria. Each citation that met one of the exclusion criteria at the title, abstract, or full-text screening phases were excluded. Studies included in the full-text screening stage were those that met all inclusion criteria and none of the exclusion criteria, or those whose eligibility could not be established during title/abstract screening. Reasons for exclusion were documented at the full-text screening phase. A total of 261 records were identified for full-text screening. This screening process led to the identification of 20 studies which were considered adequate regarding the content and methodological rigor. The data extraction focused on the outcomes of the studies, the methods used to obtain the outcomes, and the validity and reliability of those methods using a data extraction form.
Data extracted from the 20 included studies were analyzed using descriptive statistics methods and cross tabulation analysis. In addition to existing tables in the first version of the submitted manuscript, cross tabulation analysis between outcomes of interest and types of interventions was added. In the same vein cross tabulation analysis between methods of analysis used in the included studies and the types of

publications was also added. A risk of bias assessment was conducted to determine the rigour of methodology of the included studies. The rating of the studies was done by considering several domains of risk of bias suggested by Sterne et. al (2016).

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research guidelines for submitting code & software for further information.

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Behavioural & social sciences study design

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Study description	This study is a systematic review that analyzes the effect of skills training on youth engagement in the agricultural sector in developing countries. it uses systematic method to identify, appraise, and synthesize all relevant studies related to skills training interventions on youth and their engagement in agriculture. The data used in this study include both qualitative and quantitative informations.
Research sample	The targeted population is both educated and non-educated youth from developing countries. The review is on interventions that consist of skills training including agriculture-related courses, general education, on the job training, technical or vocational education and training, as well as general skills training including entrepreneurship, financial literacy, and life skills. The outcomes of interest are all employment outcomes related to the agricultural sector. These outcomes are jobs created in the agricultural sector, self-employment and entrepreneurship, provision of extension services, differences in profit/income/earnings from an agricultural activity or job, farm productivity (including yields), and accessing employment opportunities in the sector.
Sampling strategy	Inclusion criteria was based on studies that include: - Educated and non-educated youth (young men and women); - Youth employment in agriculture; - Job creation in agriculture - Agriculture, Agricultural productivity, Agricultural value chain, Agribusiness, Contract farming, Agricultural entrepreneurship; - Skill training, Occupational Skills Training, On-the-job training, Enterprise skills, Business skills, Agricultural training programs; - Published from 1990 to 2019 in English and French; - Original research and/or review of existing research - International institution reports - Youth participation/involvement in agriculture
Data collection	An exhaustive search strategy was developed and tested in CAB Abstracts to identify all available research pertaining to effects of skills training interventions on educated and non-educated youth employment outcomes in agriculture in developing countries. Search terms were developed to address variations of the key concepts in the research question: skill training, youth, employment or engagement, and agriculture. Searches were performed on May 9, 2019 in the following electronic databases: CAB Abstracts (access via OVID); Web of Science Core Collection (access via Web of Science); EconLit (access via ProQuest), Agricola (access via OVID), and Scopus (access via Elsevier). Full search strategies for each database, including grey literature, can be accessed in their entirety at https://osf.io/xv56k/. The results from the databases and the grey literature searches were combined and de-duplicated using a Python script. Duplicates were detected using title, abstract and same year of publication, where year of publication was a match, where title cosine similarity was greater than 85%, and abstracts cosine similarity greater than 80% or one of abstracts (or both) was empty. When duplicates were found, the citation priority order was Scopus, CAB Abstracts, Web of Science, Agricola, EconLit, and followed by grey literature sources. Systematic review software, Covidence, was used for both title/abstract and full-text screening decision-making with two independent reviewers evaluating each item. Citations were included in this study if they met all of the inclusion criteria noted above. Each citation that met one of the exclusion criteria at the title, abstract, or full-text screening phases were excluded. Studies included in the full-text screening stage were those that met all inclusion criteria and none of the exclusion criteria, or those whose eligibility could not be established during title/abstract screening. A total of 261 records were identified for full-text screening. This screening process led to the identification of 20 studies which were considered adequate regarding the content and methodological rigor. The data extraction focused on the outcomes of the studies, the methods used to obtain the outcomes, and the validity and reliability of those methods using a data extraction form.

Timing	Searches were performed on May 9, 2019
Data exclusions	Studies that did not meet all of the aforementioned inclusion criteria were excluded. Exclusion criteria were the inverse of the inclusion criteria. Each citation that met one of the exclusion criteria at the title, abstract, or full-text screening phases were excluded.
Non-participation	The abstract review process started with 4,789 articles. After full-text screening, 261 remained. During full-text review we excluded 241 records to retain 20 articles.
Randomization	Using Covidence, candidate studies have been randomly assigned and double blinding screened by the team members. Each study was reviewed for relevance by two independent reviewers. Each study that meets all the inclusion criteria was included. All conflicts between reviewers were resolved in Covidence by a third, independent reviewer.

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We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

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☐	☒ Human research participants
☒	☐ Clinical data
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Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Human research participants

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Population characteristics	See above
Recruitment	There are a variety of types of bias to be considered in a systematic review including publication bias, reporting bias and included study bias. In order to reduce risk of bias two separate researchers extracted data from each included study in the full text review step. When disagreements occurred between researchers on data extracted from a study, a third researcher was engaged to resolve conflict by extracting data again from the study and the results were compared to those found previously. In total, 31 conflicts were solved among the 261 reviews.
Ethics oversight	Ceres2030, Cornell University, USA

Note that full information on the approval of the study protocol must also be provided in the manuscript.