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Effect of Productive Safety Net Program On Livelihood of Smallholder Farmers in Ethiopia: Meta-Analysis

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ABSTRACT: *One way of mitigating smallholder farmers' vulnerability to shocks is through expanding productive safety net program in rural area which highly affected with drought and climate change. The major aim of safety net program is to build asset accumulation and to reduce food insecurity. Several numbers of scholars have made investigation on PSNP to know the effect of it on livelihood outcome and the obtained results were contradicted (positive, negative and no effect). Hence, this meta-analysis was aimed to direct and quantify the effect of safety net program on livelihood outcome (food security, income, asset accumulation and livestock holding) from the literature with productive safety net program. Based on inclusion and exclusion criterion, 20 studies published from 2011 to 2022 were included during this meta-analysis. Random effect model was used to evaluate the effect size of productive safety net intervention on farmer's outcome in Ethiopia. Results of random effect model confirmed that program intervention were positive and significant effect on food security. Therefore, policy makers and other stakeholders should expand productive safety net program in rural areas which exaggerated with natural disaster in Ethiopia.*

KEYWORDS: productive safety, net program, livelihood, smallholder farmers, Ethiopia, meta-analysis

INTRODUCTION

Most smallholder farmers in developing country affected with various unpredictable risks and uncertainty specifically climate change. With consequence of risk and uncertainty the farmers are being food insecure and unable to meet their demand (Abdulhafiz, 2021). As a result, Ethiopian government and other stakeholder have setup various strategies and program for reducing food insecurity. Productive Safety Net Program is one of the most effective programs began by the government to support people living in rural areas since 2005.

Ethiopia Safety Net program is the second largest in Africa (Cochrane and Tamiru, 2016). It addresses transitory and chronic food insecurity, enabling asset accumulation and serving as strategy for risk management (Cochrane and Tamiru, 2016; Abdulhafiz, 2021; HPN, 2022). Moreover, PSNP improves agricultural productivity indirectly through giving rehabilitation on adoption of agricultural technology input (Gilligan et al., 2009; Hoddinott *et al*., 2012; Araya and Holden, 2018), land management (Fitsum and Kidanemariam, 2013).

Several studies have been conducted on the impact of productive safety net program on livelihood in Ethiopia. Some studies report that PSNP improves household food security (Gilligan *et al*., 2009; Berhane et al., 2014; Porter & Goyal, 2016, Abduselam *et al*., 2018), consumption (Devereux *et al*., 2006; Yibrah, 2014), and livestock holding and productive asset (Andersson et al., 2009; Fitsum and Kidanemariam, 2013; Yibrah, 2014; Berhane *et al.*, 2014; Debela & Hollden, 2014; Gilligan *et al*., 2009; Hoddinott *et al.*, 2012). Even though PSNP reduces food insecurity and preventing asset depletion, many PSNP members remain vulnerable to health shocks in rural Ethiopia (EDRI, 2017). In addition, few studies reported no impact of PSNP on food security (Bahru *et al.*, 2021), on number of child meals per day (Gilligan et al., 2009; Bahru *et al.*, 2021), household dietary diversity, and consumption expenditure per capita (Gebrehiwot & Castilla, 2018; Tafere & Woldehanna, 2012). Hence, generalize the effect of productive safety net program on livelihood is complicated at national level. This calls Meta-analysis to assess the effectiveness of program intervention on livelihood by aggregated 20 studies conducted on this title in Ethiopia.

MATERIALS AND METHODS

In this study PSALSAR (Protocol and Reporting result with Search, Appraisal, Synthesis, and Analysis) were used to select articles to be included in Meta-analysis. The PSALSAR is a combination of two major framework used for preparing systematic literature review such as PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) and SALSA (Search, Appraisal, Synthesis, and Analysis) (Wondimagegn *et al.*, 2020). This PSALSAR framework follows six steps to conduct systematic review and meta-analysis. As a result, this study follows six stage of PSALSAR for conducting meta-analysis.

The study of meta-analysis was conducted on the effect of productive safety net program on livelihood of rural household/smallholder farmers in Ethiopia. This indicates the protocol of systematic review and meta-analysis which enforces the articles to be PICOS (population, intervention, comparison, outcome and synthesis) for evaluating cause-effect relationship. In this study productive safety net program is intervention; rural household/smallholder farmers are population; participants and non-participants in the program is comparison; and synthesis the effect of the program on livelihood of smallholder's farmers.

After identified the population, intervention and outcome to be conducted for analyzing, different search strategies were employed by using various terminology for getting information/data needed for evaluating the given objective. To obtain the required data the words and statement of TITLE and KEYWARD were used separately or combined by various conjunction such as "AND," "OR." And also searching string were employed as follows, effect/ impact/ role/contribution/ beneficial of safety net program, productive safety net program, social protection program on livelihood outcome such as welfare, livestock holding, asset accumulation, food security and income. The search databases for this study were Google scholar, pub-mad, direct science. The articles were peer-reviewed journals from the data sources and literature searches were finalized on 29 June 2022. The search was conducted in these various internationally recognized databases to collect relevant information from publications. The publication article search was restricted to those which were published between the years 2005 and 2022. The reason was that 2005 year is the time in which productive safety net program had launched by Ethiopian government to reduce food insecurity. Moreover, this year is a period in which MALES ZENAWI, who was the former of Ethiopian prime minister of EPDRF, stated that Ethiopian people will not be food insecure after 2005 year (EUDE, 2016). Therefore, this meta-analysis was conducted to evaluate whether the program has been achieving its objectives or not.

After related literatures have been searched, screening the selected literature was conducted to identify studies which should be included in meta-analysis through inclusion criteria and quality assessment. The inclusion and exclusion criteria used in this study were described in table 1.

Table 1: The exclusion and inclusion criteria for systematic review and meta-analysis

Criteria	Decision
When the predefined keywords exist as a whole or at least in title, keywords or abstract section of the paper.	Inclusion
The paper published in a scientific peer-reviewed journal	Inclusion
The paper should be written in the English language	Inclusion
Studies that present contribution of productive safety net program	Inclusion
When the articles consist at least one of livelihood outcome	Inclusion
Studies conducted in Ethiopia	Inclusion
Studies that stratified population into participant and non-participant	Inclusion
Studies which employed propensity score matching model	Inclusion
Studies conducted other countries rather than Ethiopia	Exclusion
Papers that are duplicated within the search documents	Exclusion
Papers that are not accessible, review papers and meta-data	Exclusion
Papers that are not primary/original research	Exclusion
Papers that got published before 2005	Exclusion

Source: modified from Wondimagegn *et al.*, (2020)

The general screening processes and the flow of selecting relevant literature were presented in Fig.1. First, study titles were checked for suitability for this meta-analysis. Accordingly, 577 studies obtained through literature search, 120 studies were discarded as they had been conducted out of Ethiopia. Secondly, titles of 457 studies were critically reviewed and removed 342 due to duplication, grey literature and reviewed article. As a result, 115 studies were included for full text assesses eligibility.

Thirdly, 115 studies were read for full text eligibility. Based on sampling technique that stratifying smallholder farmers into treated and control group to evaluate impact of the program, 78 more studies were discarded. Fourthly, 17 studies were excluded from 37 studies due to it didn't use propensity score matching and not cross-sectional data design. Finally, 20 selected studies have passed the inclusion and exclusion criterion and employed for meta-analysis (figure 1).

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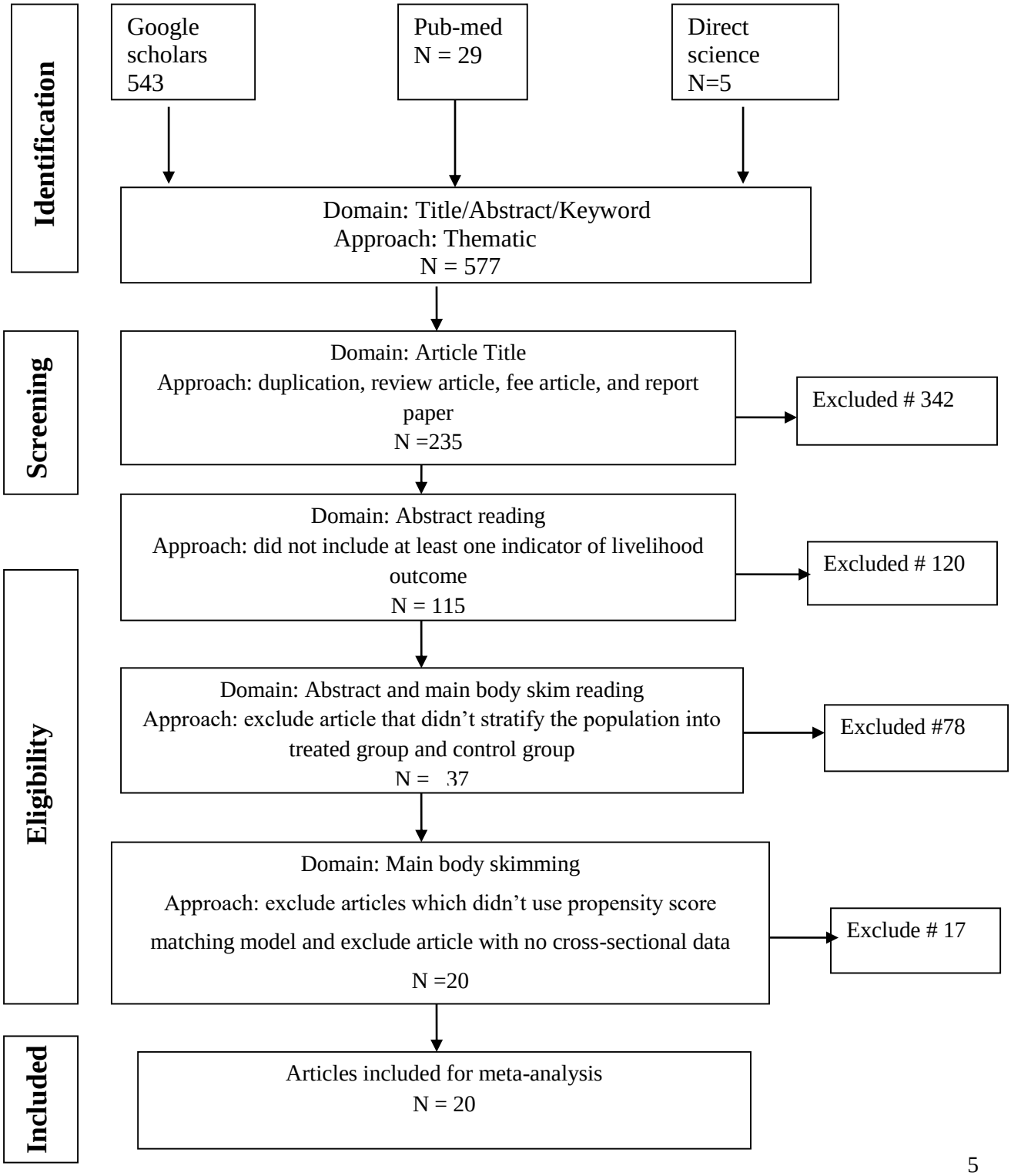

Fig. 1. The flow diagram of PRISMA modified from Wondimagegn et al. (2020)

In this case five articles were counted two wise since each of them had two outcome required to be included in meta-analysis. Even though this study included 20 articles in reality, the article inserted into data analyze were 26 since six studies with two outcomes were counted as independent article. The method was similar to the study conducted meta-analysis by Bekele (2020).

To evaluate the impact of productive safety net program on livelihood of smallholder farmers, the information needed for synthesis such as name of authors, years of publication, analysis model, and types of study design and region were summarized in (Table 2). Finally, the data related to each selected paper was extracted into an Excel spreadsheet for data processing

The extracted data can be analyzed through fixed effect model and random effect model. One researcher could select either of the two model based on suspecting the existence of difference between the outcome of treated and control group (Brenstein *et al.*, 2009). Now, this study was not conducted on experimental design so that it was suspected with risk factor that causes outcome varies between the groups rather than sample size. Therefore, random effect model was used to synthesize the standard mean difference (SMD) to generalize the effect of program on outcome since all outcome variable were continuous **(**Brenstein *et al.,* 2009**)**. For such matter STATA version16 software was used for analyze random effect model.

Moreover, much information can be reported by meta-analysis, the existence of heterogeneity and its interpretation. The status of heterogeneity was assessed using I^2 (I^2 = 0, no heterogeneity; I^2 = 25%, low; I^2 = 50%, medium and, I^2 = 75%, high heterogeneity) **(**Higgins *et al.,* 2003**).** If there is high heterogeneity, subgroup analysis will be done to partition the effect based on outcome **(**Sedgwick, 2013**).** Hence, the sign and effect size of each outcome was portrayed in the forest plot graph. The way of suggesting significant and interpretation between a given groups was proposed (Cohen's, 1988).

Cohan's suggested that d values of 0.2, 0.5, and 0.8 represent small, medium and large effect sizes respectively. This guidance was set, SMD values of 0.2-0.5 are considered small, values of 0.5-0.8 are considered as medium, and > 0.8 are considered large. If the SMD is negative, the mean of experimental group is less than the control group; if SMD is zero, there is no mean difference between two comparisons group. Moreover, if the 95% CI for the SMD includes '0', the SMD is not statistically significant.

Table 2: Identified studies to be included in meta-analysis

No	Authors	year	Region	Model	Outcome	Study design
1	Gardie	2016	Amhara	Psm	Income	Cross-sectional
2	Mada & Menza	2015	SNNP	psm	Income	Cross-sectional
3	Abduselam	2017	Somalia	Psm	Income	Cross-sectional
4	Zerhun	2020	SNNP	Psm	Income	Cross-sectional
5	Tadela	2011	Oromia	Psm	Income	Cross-sectional
19	Aregash & Zerihun	2022	Oromia	Psm	Income	Cross-sectional
6	Walelign et al.	2019	Amhara	Psm	Asset accumulation	Cross-sectional
7	Fitsum	2013	Oromia	Psm	Asset accumulation	Cross-sectional
8	Zerhun	2020	SNNP	Psm	Asset accumulation	Cross-sectional
9	Tadela	2011	Oromia	Psm	Asset accumulation	Cross-sectional
10	Abdulhafiz	2021	Amhara	Psm	Asset accumulation	Cross-sectional
11	Fitsum	2013	Oromia	Psm	Livestock holding	Cross-sectional
12	Mada & Menza	2015	SNNP	Psm	Livestock holding	Cross-sectional
13	Tadela	2011	Oromia	Psm	Livestock holding	Cross-sectional
14	Dessalcgn & Feyera	2013	SNNP	Psm	Livestock holding	Cross-sectional
15	Gardie	2016	Amhara	Psm	Livestock holding	Cross-sectional
16	Megos	2019	Tigrai	Psm	Livestock holding	Cross-sectional
17	Zenebe & Aad	2012	Oromia	psm	Livestock holding	Cross-sectional
18	Gelagay	2016	Tigrai	psm	Livestock holding	Cross-sectional
19	Aregash & Zerihun	2022	Oromia	Psm	Food security	Cross-sectional
20	Abduselam et al.	2018	Somalia	Psm	Food security	Cross-sectional
21	Walelign et al.	2019	Amhara	Psm	Food security	Cross sectional
22	Mada & Menza	2015	SNNP	Psm	Food security	Cross-sectional
23	Andualem	2020	Amhara	Psm	Food security	Cross-sectional
24	Abduselam	2017	somalia	Psm	Food security	Cross-sectional
25	Zerhun	2020	SNNP	PSM	Food security	Cross-sectional

After analysis the effect size, testing publication bias is needed for checking the existence of publication bias which had been included in meta-analysis. Publication bias could be checked through different ways such as funnel plot, Begg tests and egger tests. These tests can be selected based on the number of studies included in meta-analysis. Funnel plot must be employed when number of studies greater than ten is included in the quantitative synthesis (Sterne *et al.*, 2011). Begg Test is a nonparametric test that only reaches enough statistical power to detect publication bias when the researchers include greater than twenty five studies (Gjerdevik *et al.*, 2014). Egger test has more statistical power than the Begg test and is generally used to detect publication bias when the MA includes between 10 - 25 studies (Sterne *et al.*, 2011). Therefore, Egger test were used in this study to detect the existence of publication bias. For suggesting the evidence existence

of publication bias, the P-value should be less than 0.05 (Lifeng Lin *et al.*, 2016). There were also non-parametric trim and fill analysis of publication bias. Meta-analysis is a popular technique for numerically synthesizing information from published studies. Trim and fill analysis addresses bias in estimating the overall meta-analytical effect (Z Liu *et al.*, 2013). As a result, this study of meta-analysis employed Egger tests and trims and fills analysis for diagnosed publication bias.

Measurements and definition of variables included in meta-analysis

Intervention/Treatment variable: productive safety net program. PSNP is dummy variable which is measured by whether smallholder farmers participated in the program or not. Outcome variable: food security, consumption expenditure, asset accumulation, income and livestock holding. Food security is a continous variable which is measured with kilocalorie intake. Asset accumulation is a countinous variable which is measured in monetary value means Ethiopian birr (ETB). Income is a continous variable that is measured by ETB. The last variable included in meta-analysis is livestock holding which is measured by tropical livestock unit.

RESULTS AND DISCUSSION

The effect of productive safety net program on the livelihood of smallholder farmers

The result and discussion presented in meta-analysis were reported based on PSALSAR criteria. The overall result from table 2 indicated that farmers who have participated in productive safety net program can improve their livelihood by 0.2, as compared to farmers who have no participated. The model output also indicated the I^2 value of 97.88% which is within the range of high heterogeneity. This heterogeneity could be due to study variation with different livelihood outcome in the study. Therefore, subgroup analysis on livelihood outcome (income, asset accumulation, livestock holding and food security) were employed. The sub group analysis is represented using the forest plot diagram as shown in Fig. 2 below.

Table 2: summary of subgroup meta-analysis

Subgroup meta-analysis summary Random-effects model Method: DerSimonian-Laird		Number of studies = 26	
Study	SMD	[95% Conf. Interval]	% Weight
Group: 1= income			
Gardie (2016)	0.095	-0.14 0.331	3.97
Mada & Menza (2015)	0.041	-0.279 0.361	3.7
Abduselam (2017)	0.032	-0.278 0.342	3.74
Zerhun (2020)	0.602	0.381 0.823	4.01
Tadela (2011)	0.045	-0.243 0.333	3.81
Aregash & Zerihun (2022)	0.022	-0.271 0.316	3.79
theta	**0.151**	**-0.060 0.363**	
Group: 2 = Asset accumulation			
Walelign et al. (2019)	-0.142	-0.421 0.137	3.84
Fitsum Aklilu (2013)	0.61	0.288 0.932	3.69
Zerhun (2020)	0.78	0.489 1.071	3.80
Tadela (2015)	-0.065	-0.206 0.076	4.21
Abdulhafiz (2021)	0.13	-0.137 0.397	3.88

theta	**0.251**	**-0.091**	**0.594**	
Group: 3 = livestock holding				
Fitsum (2013)	0.204	-0.142	0.549	3.61
Gardie (2016	0.041	-0.174	0.257	4.03
MADA & MENZA (2015)	0.052	-0.268	0.372	3.7
Tadela (2011)	-0.128	-0.171	-0.085	4.34
Dessalcgn & Feyera (2013)	-0.725	-0.772	-0.678	4.33
Megos. D (2019)	0.143	-0.523	0.809	2.47
Zenebe & Aad (2012)	-0.123	-0.437	0.191	3.72
GELAGAY (2016)	0.017	-0.007	0.041	4.35
theta	**-0.089**	**-0.358**	**0.180**	
Group: 4 = food security				
Aregash & Zerihun (2022)	0.370	0.092	0.648	3.84
Abduselam et al. (2018)	0.610	0.216	1.004	3.44
Walelign et al. (2019)	-0.089	-0.41	0.232	3.7
MADA & MENZA (2015)	0.750	0.534	0.966	4.03
Andualem (2020)	0.348	0.123	0.574	4.00
Abduselam (2017)	1.070	0776	1.364	3.79
Zerhun (2020)	0.740	0.601	0.879	4.04
theta	**0.550**	**0.309**	**0.791**	
Overall				
theta	**0.204**	**0.044**	**0.363**	

As a result, Productive safety net program has different magnitude effects on each of outcome such as livestock holding, food security, asset accumulation and income. As shown on Fig. 2 the result form subgroup Meta-analysis depicted the participation in productive safety net program has more effect on food security. Engaged in safety net program improves kilo calorie intake by 0.55 as compared to non-beneficiary of safety net program. The plausible reason for this result could be due to most of smallholder farmers depends rain fed for their livelihood so that their production and productivity affected by various challenges such climate change. For such reason, productive safety net program can be an issue that fills food gab happened due to the various risks with farmer's production and also it improves food security. This is in line with the finding of (Gilligan *et al.,* 2009; Berhane *et al.,* 2014; Porter & Goyal, 2016, Abduselam *et al.,* 2018) showed that productive safety net program improves food security of smallholder farmers in Ethiopia. Productive safety net program has not only designed to provide urgent social protection services but also to improve capability of households to accumulate assets. The result showed that the mean difference of the livestock holding, in terms of TLU, between the program participant and non-participant households was statistically insignificant. This result was in line with the finding of (Camilla *et al.,* 2009; Tadele, 2011; Bethelhem & Holden, 2014). The main reason hinders the achievement of productive safety net program could be wrong inclusion and exclusion (Abraham, 2020).

The subgroup analysis result portrayed that engagement in productive safety net program improves the value of asset accumulation and income by 0.151 and 0.252, respectively as compared to non-participant in the program. However, its effect was not statistically significant.
Publication bias diagnostic test were employed in the study of meta-analysis. According to Table The Egger test shows a regression intercept beta 1 is 1.75 and the p value is 0.2045. Since the p value was greater than 0.05, the effect of small study was not statistically significant. This result implies no evidence of publication bias.

Table 3: detection of publication bias using Egger test

Regression-based Egger test for small-study effects	
H0: beta1 = 0; no small-study effects	
beta1 =	1.75
SE of beta1 =	1.376
z =	1.27
Prob > |z| =	0.2045

CONCLUSION AND POLICY IMPLICATION

This study represents the first attempt to use a meta-analysis to evaluate the effect of PSNP on outcome of livelihood indicator in Ethiopian. The result of Meta-analysis revealed that the effect size of intervention of productive safety net program on kilo calorie intake was 0.55. The implication is that program has contributed positive and significant effect on food security. However, it could not bring significant effects on income, asset accumulation and livestock holding. These in turn limits farmers' participation in safety net program and weaken the efficiency of program. Thus, program designers should consider corrective measurements regarding program design and implementation to realize objective of productive safety net program.

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