

Human flourishing in the context of farm characteristics and occupational hazards – Baseline findings from the FarmCoSwiss cohort

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Summary

INTRODUCTION AND OBJECTIVES: In Switzerland, little is known about farmers' wellbeing. Based on cross-sectional baseline data from the Swiss agricultural health cohort FarmCoSwiss, we carried out a study to investigate farmers' flourishing i.e. complete wellbeing and ability to thrive – to our knowledge, the first study worldwide to do so –, to descriptively compare it to the general population and to explore its association with farm characteristics and occupational hazards.

METHODS: Of 1480 self-registered adult farmers recruited as a Swiss-wide convenience sample, 947 individuals (63.9%) signed the informed consent form, and 872 answered the online questionnaire in German, French or Italian at baseline between November 2022 and August 2023. The questionnaire obtained information on, among others, the primary outcome flourishing as assessed by the Secure Flourish Index (SFI) with its six subdomains *Happiness and life satisfaction*, *Mental and physical health*, *Meaning and purpose*, *Character and virtue*, *Close social relationships*, and *Financial and material stability*, each assessed on a scale from 0 to 10. Participants additionally answered questions on the primary predictors farm characteristics and 20 pre-selected occupational hazards classified into five domains (physical, chemical, biological, psychosocial and environmental). Participants assessed the hazards in terms of exposure frequency (Likert scale from 1 to 5) and perceived health harmfulness (Likert scale from 1 to 4). First, farmer's mean SFI was descriptively compared to mean SFI in the general adult population using the data of 7220 participants from the 2023 follow-up of the population-based COVCO-Basel cohort established in Basel-Stadt and Basel-Landschaft cantons. Second, zero-one inflated beta regression models were constructed to investigate the age- and sex-adjusted association of mean SFI values (overall; domain-specific) with the farming system (non-organic or organic), the production system (animal husbandry or crop cultivation), farm size (five categories) as well as the exposure to, and per-

ception of, occupational hazards (sum of respective Likert scales).

RESULTS: Mean SFI values were between 7 and 8, in both FarmCoSwiss and COVCO-Basel. Descriptively comparing these two samples, farmers showed lower flourishing overall (7.44, SD = 1.41; COVCO: 7.70, SD = 1.30) and in the four domains *Happiness and life satisfaction* (7.39, SD = 1.87; COVCO: 7.91, SD = 1.55), *Mental and physical health* (7.03, SD = 1.73; COVCO: 7.68, SD = 1.53), *Close social relationships* (7.66, SD = 2.08; COVCO: 7.94, SD = 1.73) and *Financial and material stability* (7.06, SD = 2.45; COVCO: 7.33, SD = 2.69). Farmers reported being most frequently exposed to biological hazards (66.2% often/always exposed), but psychosocial hazards were perceived as the most harmful to health (51.9% judging them as rather/very harmful). Exposure to psychosocial hazards was negatively associated with overall flourishing and its six subdomains. In the domains *Happiness and life satisfaction*, *Mental and physical health*, and *Meaning and purpose*, organic farming was associated with higher flourishing. In the domain *Close social relationships*, organic farming was associated with lower flourishing. The largest association was observed for farm size. Farmers with the smallest farms (<5 ha) scored low in the *Financial and material stability* domain, with a decrease in mean SFI (logit scale) of 1 as compared to farmers with the largest farms (>50 ha).

CONCLUSION: Our findings suggest a potentially lower overall flourishing among farmers as compared to a sample from the general population, with small farm size and exposure to psychosocial hazards being of particular concern, but organic farming having potential benefits. The study underscores the need for longitudinal research of farmers' wellbeing to maintain a thriving agricultural workforce.

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Introduction

The agricultural sector ranks among the most hazardous industries worldwide [1]. Farm workers face a myriad of health hazards, ranging from environmental (e.g. UV radiation), biological (e.g. pollen) and chemical exposures (e.g. plant protection products) to physical hazards (e.g. accidents) and psychosocial pressures (e.g. loneliness). In addition, farmers constantly cope with enterprise-related risks, such as production or financial risks, which are expected to be exacerbated by climate change [2]. Exposure to such occupational hazards depends on agricultural activities performed on the farm, which may in turn be impacted by specific farm characteristics such as the farming system (e.g. organic), agricultural production (e.g. crop cultivation) and farm size [3]. Numerous agricultural cohorts have been established globally to examine the associations between farmers' distinctive agricultural exposures and health effects [4–6]. These cohorts provide invaluable insights into agricultural occupational hazards and associated disease risks with sufficient latency and in a time-resolved manner [4]. Evidence from epidemiological studies, including agricultural cohorts, points to an increased risk of injuries and respiratory diseases, neurological and reproductive disorders, as well as certain cancer types in the farming workforce [7–13]. Exposures associated with these health outcomes include handling dangerous machinery, outdoor work, lifestyle factors and hazardous agents such as pesticides, dust, solvents, engine exhausts and zoonotic microbes, among others [3, 14]. Studies on the mental health of farming communities found an increased risk of suicide and identified several stressors relating to financial insecurity, environmental changes, institutional pressure and psychosocial challenges common in agriculture [15–17]. Although some of these health outcomes can be linked to specific exposures, such as pesticide use or geographical isolation, overall health is generally determined by a complex set of occupational hazards, lifestyle factors, and personal, societal, financial and environmental factors. A frequently studied factor potentially affecting farmers' mental and physical health is the farming system, i.e. conventional or organic. Studies investigating the differences in health outcomes between farming systems showed a trend towards better overall health and wellbeing in organic farmers, although results depend on the symptoms or physiological outcomes investigated [18]. For physical health outcomes, higher frequencies of accidents related to machinery use, hearing loss and acute symptoms associated with pesticide use such as skin rashes, headaches and dizziness have been reported for conventional farmers [19–21]. In contrast, other studies report higher frequencies of chest pain and musculoskeletal pain in organic farmers or no difference between organic and conventional farmers [19, 22, 23]. Findings regarding the psychological and neurological health differences between organic and conventional farmers are inconclusive. While some studies found lower rates of depression and fewer neurological symptoms in organic farmers, other studies report no difference between the two farming systems [24, 25].

Given the numerous health and agro-economic challenges farmers face, it is important to consider a comprehensive approach to study farmers' overall health, which is defined as a state of wellbeing and not merely the absence of dis-

ease [26]. The term wellbeing often relates to psychological and social wellbeing as measured by the state of happiness or life satisfaction [27]. The broader concept of flourishing refers to complete human wellbeing beyond one's mental state and comprises being able to fulfil a purpose and thrive [28]. While wellbeing has been investigated in agricultural health research, we are not aware of any study investigating human flourishing in farmers [6].

Due to this dearth of evidence, the first Swiss national farmer cohort FarmCoSwiss was implemented in 2022 (www.swisstph.ch/farmcoswiss). The cohort aims to contribute to closing the evidence gap regarding the state and the future temporal course of health, wellbeing and flourishing of Swiss farmers and their partners. This study is based on a cross-sectional analysis of the baseline data to examine human flourishing in participating farmers, to descriptively compare flourishing between the farming and the general populations and to explore its association with farm characteristics and exposure to, and perception of, occupational health hazards.

Materials and methods

Study participants and sampling procedure

The prospective FarmCoSwiss cohort was initiated in Switzerland in 2022 within the interdisciplinary “Transformation in Pesticide Governance” (TRAPEGO) project (www.trapego.ch) to assess occupational exposures, physical and mental health outcomes, as well as human flourishing in agricultural workers and their partners living on or off the farm. We will briefly describe participant recruitment and data collection here – detailed information on the aims and methods of the FarmCoSwiss study have been published elsewhere [29]. To be eligible, individuals had to (a) be at least 18 years old, (b) speak one of the three national languages (German, French or Italian), (c) be working (part-time, full-time or unpaid) in agriculture or have a partner engaged in agriculture, and (d) be residing in Switzerland with a long-term perspective. As access to a national agricultural workforce registry was not available and because the primary focus of a cohort is on keeping loss-to-follow-up low, a convenience sample of individuals was reached through print and digital flyers broadly distributed in farmer associations' and agricultural enterprises' newsletters, at agricultural events and through advertisements in agricultural newspapers. Interested individuals self-registered on the study website through the web-based data capture and management tool REDCap (Research Electronic Data Capture) hosted at the Swiss Tropical and Public Health Institute; they subsequently received detailed study information and an informed consent form by post [30, 31]. The success of this sampling procedure was monitored to increase participation rate and maximise representativeness concerning sex, age and farming system. Potential participants were invited for enrolment between November 2022 and April 2023. The online registration tool remained open until 2 August 2023. Ethical clearance was obtained from the regional ethics committee Ethikkommission Nordwest- und Zentralschweiz (EKNZ) (BASEC No. 2022-00549).

Data collection

Enrolled individuals received the baseline questionnaire either as a personalised e-mail with a link to an online questionnaire in REDCap or as a print version by post in their preferred language (German, French or Italian; see supplementary file available for download at <https://doi.org/10.57187/s.4135> for full questionnaires in these languages). In the survey, subjects were first asked about their education and employment. Subsequently, data was collected on the farming system, agricultural production, household structure, health-related factors (including health-related quality of life [HRQoL], sleep, stress, lifestyle and medical diagnoses), as well as occupational hazard exposure and perception.

Validated questionnaire instruments used included the SF-12 v2 for health-related quality of life, the Secure Flourish Index (SFI) for overall wellbeing, the Single-Item Physical Activity Measure (SIPAM) for physical activity and the Behavioral Risk Factor Surveillance System for medical diagnoses [32–35]. Instruments about lifestyle factors, sleep and stress used in the baseline survey were aligned with questions posed in the Swiss Health Survey and other cohort studies conducted in Switzerland, such as SAPALDIA (Study on Air Pollution And Lung Disease In Adults) and COVCO-Basel [36–38].

The *primary outcome*, human flourishing, was measured by the SFI, which encompasses doing or being well in the following six domains: (1) happiness and life satisfaction, (2) mental and physical health, (3) meaning and purpose, (4) character and virtue, (5) close social relationships and (6) financial and material stability. The SFI is a short metric that offers the opportunity to measure the complex and multidimensional concept of flourishing on a scale from 0 to 10, with a higher value representing higher flourishing [33]. Although the SFI was not developed specifically to be used in workplace settings, it has been tested in office and manufacturing industry settings and proved to be useful in assessing human flourishing in occupational health research [39].

The *primary predictors* of interest included different farm characteristics, including farming systems, production system and farm size. The variable *Farming system* was categorised as non-organic or organic. While organic farming in Switzerland refers to the common definition of organic food production, i.e. without synthetic fertilisers or pesticides, the generally accepted definition of “conventional agriculture” in the literature does not necessarily correspond to the Swiss agricultural environment. In Switzerland, the so-called “proof of ecological performance” (*ökologischer Leistungsnachweis* in German) refers to a minimum ecological production standard. The proof of ecological performance sets requirements in areas such as, for example, soil protection, plant protection products and biodiversity. It is also a prerequisite for receiving direct payments, which were received by around 90% of Swiss farms in 2019 [40, 41]. Furthermore, Switzerland has adopted the integrated pest management (IPM) approach, which states that chemical control measures should only be used when non-chemical and preventive measures are unable to provide adequate crop protection. About 40% of farms in Switzerland are integrated production (IP-SUISSE)-certified [42]. Thus, differences concerning envi-

ronmental and biodiversity protection between non-organic and organic farming systems in Switzerland may not be as pronounced as in other country settings. Hence, the term “non-organic” is used here and includes farms with production according to proof of ecological performance or any other non-organic standards (e.g. IP-SUISSE).

In addition, *primary predictors* of interest also encompassed exposure to and perception of different occupational hazard domains. Participants assessed 20 predefined occupational tasks, events or situations (referred to as “hazards”) with regard to (a) the self-reported frequency of exposure to the specific hazard (referred to as “exposure”) and (b) the perceived health harmfulness of the specific hazards regardless of the exposure frequency (referred to as “perception”). Exposure to and perception of the hazards were measured on a 5-point and 4-point Likert scale, respectively. The occupational hazards were divided into five domains, namely (1) physical, (2) chemical, (3) biological, (4) psychosocial and (5) environmental hazards. The hazard selection was first derived from questionnaires of the Agricultural Health Survey and scientific literature, and in a second step revised after feedback from pilot tests with farmers and experts from the Swiss agricultural sector [43–46]. Figure 1 lists the four individually assessed hazards in each of the five hazard domains.

Statistical analysis

Study population characteristics were analysed by descriptive measures. Continuous variables are presented as mean and standard deviation (SD) or median and range. Categorical variables are expressed as counts and percentages.

The cross-sectional association between human flourishing (overall and subdomain-specific) and selected variables was investigated using zero-one inflated beta regression models with logit link, given the scale from 0 to 10 and the negatively skewed distribution of the SFI. The total mean and domain-specific mean values of the SFI were calculated and divided by maximum values to generate values between, and including, 0 and 1. Throughout the manuscript, results referring to a change in the SFI as the outcome variable will be interpreted on the logit scale. Explanatory variables were selected a priori and included three farm characteristic variables (*farming system*: non-organic or organic; *production system*: crop cultivation [without animal husbandry] or animal husbandry [with or without crop cultivation]; *farm size* [hectares]: <5, 5–10, 11–20, 21–50 or >50) as well as self-reported exposure frequency and perceived health harmfulness per hazard domain. For the hazards, domain-specific exposure and perception measures were computed by calculating the sum of all Likert scores per hazard domain. Age (continuous) and sex (female or male) were included a priori as confounders.

The above-listed primary predictors (farm characteristics; hazard exposure and perception) and confounders (age; sex) were all added to the same model. Collinearity between the hazard components was investigated before running the regression models by means of correlation matrices. None of the five hazard domains had a Spearman correlation coefficient higher than 0.54 (see figure S1 in the appendix). Subjects with missing data for any of the primary outcome, predictor or confounder variables were excluded from the respective analysis, as missing values

were below 5% for all variables of a priori interest. In sensitivity analyses, the mean SFI and SFI subdomain models were ran with a random intercept to account for clustering on the farm level (individuals living on the same farm, based on a specific farm ID given to each individual after registration). Regression coefficients of main effects with p-values below 0.20 were considered for interpretation, and p-values below 0.05 were deemed statistically significant. Statistical analyses were conducted in R 4.2.1 using the *glmmTMB* function with the *ordbeta* family from the *glmmTMB* package 1.1.9 [47]. A simplified code for the regression analyses and respective figures can be found on Zenodo (<https://doi.org/10.5281/zenodo.14426872>).

Lastly, to put the findings about flourishing among farmers into perspective and to explore potential differences between farmers and the general population in Switzerland, FarmCoSwiss SFI data was descriptively compared (mean; SD) to flourishing data from the COVCO-Basel cohort study, a population-based SARS-CoV-2 cohort of adults initiated in 2020/2021 in two Swiss Cantons (one urban, Basel-Stadt, and one periurban/rural, Basel-Landschaft) with more than 10,000 adult participants from the general population. Details on the aims and methods of the COVCO-Basel study have been published [38]. Briefly, the digital cohort was initiated to examine the long-term impact of COVID-19 containment measures in Switzerland on physical and mental health. Between July 2020 and March 2021, eligible individuals were invited by post from same-sized canton- and age-stratified random samples provided by the Federal Statistical Office and answered a baseline and repeated follow-up online questionnaires. The COVCO-Basel study population was comparable to the general population in the two cantons with regard to sociodemographic factors, including sex. Ethical approval was obtained by the regional ethics committee (EKNZ

2020-00927) and all participants provided informed consent prior to enrolment in the COVCO-Basel study. For the comparison of the total mean and domain-specific mean SFI scores between the FarmCoSwiss and the COVCO-Basel cohorts, we used follow-up data of 7220 COVCO-Basel participants from the year 2023 in order to be temporally aligned with the FarmCoSwiss baseline survey. The statistical significance of these exploratory comparisons was not assessed.

Results

Characteristics of study participants

Table 1 summarises FarmCoSwiss study participants' characteristics and flourishing, stratified by non-organic versus organic farmers. Of the 1480 individuals who self-registered through the study website, a total of 947 farmers returned a signed informed consent form and were therefore fully registered as participants. Of these, 875 answered at least part of the questionnaire before it was closed, and 863 completed the questionnaire. Answers from participants who at least partially completed the questionnaire and worked in agriculture were included in the analysis (n = 872). Two thirds of participants (n = 575, 65.9%) were male and the age range of the total study sample was 21 to 86 years. Only 82 participants (9.4%) were exclusively active in crop production, whereas the vast majority (n = 782, 89.7%) reported animal husbandry alone or combined with crop production. More than half of the participants (n = 529, 60.7%) worked on farms of more than 20 ha. There were no substantial differences in population characteristics between non-organic and organic participants.

Figure 1: Occupational hazards assigned to five domains, self-assessed by participants with regard to exposure frequency and perceived health harmfulness.

				
Physical	Chemical	Biological	Psychosocial	Environmental
Heavy physical work	Fertilizers	Pollen / spores	Conflicts	UV radiation
Handling heavy machinery	Plant protection products (PPPs)	Dust	Sleep problems	Heavy storms
Work at height / in uneven terrain	Gases / fumes	Animal contact / animal excretions	Stress	Landslides / avalanches
Prolonged sitting	Strong detergents	Insect bites / stings	Loneliness	Noise

Mean SFI in the total study sample was 7.44 (SD = 1.41). Mean SFI was slightly higher among organic farmers in all but the *Character and virtue* and *Close social relationships* domains. In the complete study population as well as in the non-organic and organic subsamples, mean SFI was highest in the *Meaning and purpose* SFI domain (total: 7.89, SD = 1.90; non-organic: 7.79, SD = 1.94; organic: 8.27, SD = 1.70). In the non-organic subsample, lowest SFI scores were reported in the *Mental and physical health* SFI domain (6.94, SD = 1.78). In the organic subsample, lowest SFI scores were reported in the *Financial and material stability* domain (7.16, SD = 2.44). An overview of the frequency distribution of the total mean SFI and domain-specific mean SFI in the total sample as well as in the non-organic and organic subsamples can be found in the appendix (figure S2).

Comparison of flourishing with the COVCO-Basel cohort

The SFI distribution in our farmer cohort was comparable to the flourishing distribution of the general population participating in the COVCO-Basel cohort [48]. Table 2 shows total mean and domain-specific SFI values in both cohorts, and separately for COVCO-Basel participants from Basel-Stadt (urban) and Basel-Landschaft (periurban and rural) (see appendix, table S1 for age- and sex-stratified comparisons). Mean SFI values overall and for each domain were between 7 and 8 in both cohorts. FarmCoSwiss participants reported potentially lower mean values for the overall SFI (7.44 ± 1.41) and for the four domains *Happiness and life satisfaction* (7.39 ± 1.87), *Mental and physical health* (7.03 ± 1.73), *Close social relationships* (7.66 ± 2.08) and *Financial and material stability* (7.06 ± 2.45) as compared to COVCO-Basel participants from urban and rural settings. In the domains *Meaning and purpose* and *Character and virtue*, FarmCoSwiss participants' mean SFI was comparatively higher than in ur-

Table 1:
FarmCoSwiss participant characteristics and flourishing at baseline, stratified by farming system.

		Total	Non-organic	Organic
Participants, n (%)		872 ^a	675 (77.4%)	195 (22.4%)
Sex	Female, n (%)	297 (34.1%)	229 (33.9%)	66 (33.8%)
	Male, n (%)	575 (65.9%)	446 (66.1%)	129 (66.2%)
Age in years, mean (median, range)		48.8 (49, 21–86)	48.9 (49, 21–86)	48.4 (49, 28–79)
Production system, n (%)	Animal husbandry ^b	782 (89.7%)	602 (89.2%)	179 (91.8%)
	Crop production	82 (9.4%)	67 (9.9%)	14 (7.2%)
	NA	8 (0.9%)	6 (0.9%)	2 (1.0%)
Farm size in hectares, n (%)	<5	29 (3.3%)	23 (3.4%)	6 (3.1%)
	5–10	71 (8.1%)	55 (8.1%)	16 (8.2%)
	11–20	243 (27.9%)	182 (27.0%)	61 (31.3%)
	21–50	429 (49.2%)	335 (49.6%)	92 (47.2%)
	>50	100 (11.5%)	80 (11.9%)	20 (10.3%)
Farm ownership, n (%)	Participant	588 (67.4%)	457 (67.7%)	131 (67.2%)
	Partner/family member	243 (27.9%)	193 (28.6%)	48 (24.6%)
	Unrelated person or institution	37 (4.2%)	23 (3.4%)	14 (7.2%)
	NA	4 (0.5%)	2 (0.3%)	2 (1.0%)
Job position, n (%)	(Co-)manager	655 (75.1%)	507 (75.1%)	147 (75.4%)
	Employee	205 (23.5%)	158 (23.4%)	46 (23.6%)
	Other	5 (0.6%)	4 (0.6%)	1 (0.5%)
	NA	7 (0.8%)	6 (0.9%)	1 (0.5%)
Work load, n (%)	Full-time	656 (75.2%)	504 (74.7%)	151 (77.4%)
	Part-time	195 (22.4%)	153 (22.7%)	41 (21.0%)
	Other (e.g. hobby)	16 (1.8%)	16 (2.3%)	0 (0.0%)
	NA	5 (0.6%)	2 (0.3%)	3 (1.6%)
SFI, mean ($\pm$ SD) ^c	Overall SFI	7.44 (1.41)	7.40 (1.42) ^e	7.60 (1.35) ^f
	Happiness and life satisfaction	7.39 (1.80)	7.31 (1.88) ^e	7.68 (1.47) ^f
	Mental and physical health	7.03 (1.73)	6.94 (1.78) ^e	7.34 (1.50) ^f
	Meaning and purpose	7.89 (1.90)	7.78 (1.95) ^e	8.27 (1.70) ^f
	Character and virtue	7.59 (1.69)	7.62 (1.64) ^e	7.50 (1.85) ^f
	Close social relationships	7.66 (2.08)	7.67 (2.09) ^e	7.60 (2.06) ^f
	Financial and material stability	7.06 (2.45)	7.04 (2.45) ^e	7.16 (2.44) ^f

^a A total of two participants could not be allocated to a non-organic or organic farming system (NA).

^b Includes any farm with animal husbandry, either with or without crop production.

^c SFI: Secure Flourish Index; SD: standard deviation.

^d Missing values (NA) = 12 for overall flourishing, *Character and virtue*, *Close social relationships* and *Financial and material stability* subdomains; NA = 14 for *Happiness and life satisfaction*, *Mental and physical health* and *Meaning and purpose* subdomains.

^e Missing values (NA) = 8 for overall flourishing, *Character and virtue*, *Close social relationships* and *Financial and material stability* subdomains; NA = 9 for *Happiness and life satisfaction*, *Mental and physical health* and *Meaning and purpose* subdomains.

^f Missing values (NA) = 3 for overall flourishing, *Character and virtue*, *Close social relationships* and *Financial and material stability* subdomains; NA = 4 for *Happiness and life satisfaction*, *Mental and physical health*, and *Meaning and purpose* subdomains.

ban COVCO-Basel. COVCO-Basel participants residing in Basel-Landschaft reported higher mean SFI values overall and for every domain. The biggest difference between mean SFI values in the two cohorts was observed in the *Mental and physical health* domain, with rural COVCO-Basel participants reporting a 0.7 scale-point higher mean flourishing (7.73, SD = 1.48) than FarmCoSwiss participants (7.03, SD = 1.73).

Descriptively comparing flourishing between men and women in both cohorts, women generally and irrespective of the cohort reported similar or slightly lower SFI mean values overall and in every domain except for the *Close social relationships* domain. Women from FarmCoSwiss reported lower mean SFI values for *Close social relationships* than men, whereas in COVCO-Basel our results suggest that women might tend to score better for this SFI domain than men (see table S1). Flourishing in both cohorts was generally higher in individuals above the age of 50 as compared to participants younger than 50 years (see table S1).

Occupational hazard description

Single hazards

An overview of each hazard's exposure and perception distribution based on participant answer frequencies is shown in figure 2. Means and standard deviations of each hazard and hazard domain are presented in the appendix for the total study population and for non-organic and organic farmers separately (see table S2 in the appendix).

Of the 20 investigated single hazards, the least common self-reported exposure was landslides/avalanches. Almost all participants (96.4%) indicated that they were never/rarely exposed to landslides/avalanches, followed by plant protection products (never/rarely: 72.8%) and loneliness (never/rarely: 72.7%). Roughly three quarters of participants (74.7%) reported being frequently (often/always) exposed to direct animal contact, dust (74.5%) and heavy machinery (70.4%).

The ranking for the perception attributed to the 20 single hazards differed partly from the ranking of the reported exposures. Handling heavy machinery was perceived as not/somewhat harmful to health by the vast majority of participants (88.0%), followed by direct contact with animals (not/somewhat: 87.9%) and pollen/spores (not/somewhat: 80.9%). Stress (78.2%), sleep problems (70.0%) and conflicts (58.9%) were perceived as rather/very harmful hazards by most participants.

Hazard domains

Of the five hazard domains, most farmers (58.8%) reported the lowest occupational exposure to chemical hazards. In comparison, two thirds of participants (66.2%) reported exposure to biological hazards as the most frequent.

With regard to the health harmfulness attributed to the five hazard domains, physical hazards were perceived to be the least harmful by most participants (42.2%) and psychosocial hazards were perceived as the most harmful by approximately half of farmers (51.9%).

Regression models on determinants of flourishing

Beta regression results of the age-, sex- and mutually adjusted model investigating the cross-sectional association of the mean SFI with farm characteristics, hazard exposure and hazard perception are shown in figure 3. Regression results (estimates, standard errors, p-values and 95% confidence intervals [CIs]) are presented in detail in the appendix (table S3). There was a trend towards lower SFI among non-organic farmers (−0.094, 95% CI: −0.199–0.009). A higher exposure to psychosocial hazards, but not their perception, was associated with lower SFI scores (−0.15, 95% CI: −0.17–−0.14). A higher exposure to physical hazards was positively associated with the SFI (0.02, 95% CI: 0.00–0.04). In contrast, there was an association trend between a higher perception of physical hazards and lower flourishing (−0.02, 95% CI: −0.04–0.00).

Results of the same models investigating the cross-sectional association between the domain-specific mean SFI and farm variables, hazard exposure and hazard perception are depicted in figure 4 (see table S4 in the appendix for de-

Table 2:

Mean overall and domain-specific Secure Flourish Index among FarmCoSwiss and COVCO-Basel cohort participants, stratified by canton for COVCO-Basel.

		FarmCoSwiss ²	COVCO-Basel ³	Basel-Stadt (urban) ⁴	Basel-Landschaft (rural) ⁵
Participants, n (%)		872 (100%)	7220 (100%)	3582 (49.7%)	3638 (50.3%)
SFI, mean (± SD)	Overall SFI	7.44 (1.41)	7.70 (1.30)	7.63 (1.35)	7.78 (1.25)
	Happiness and life satisfaction	7.39 (1.80)	7.91 (1.55)	7.85 (1.58)	7.98 (1.52)
	Mental and physical health	7.03 (1.73)	7.68 (1.53)	7.64 (1.54)	7.73 (1.48)
	Meaning and purpose	7.89 (1.90)	7.82 (1.81)	7.69 (1.88)	7.94 (1.73)
	Character and virtue	7.59 (1.69)	7.53 (1.63)	7.46 (1.65)	7.61 (1.61)
	Close social relationships	7.66 (2.08)	7.94 (1.73)	7.86 (1.76)	8.01 (1.69)
	Financial and material stability	7.06 (2.45)	7.33 (2.69)	7.25 (2.75)	7.42 (2.63)

¹ SFI: Secure Flourish Index; SD: standard deviation.

² Missing values (NA) = 12 for overall flourishing, *Character and virtue*, *Close social relationships* and *Financial and material stability* subdomains; NA = 14 for *Happiness and life satisfaction*, *Mental and physical health* and *Meaning and purpose* subdomains.

³ Missing values (NA) = 14 for overall flourishing; NA = 22 for *Happiness and life satisfaction*; NA = 24 for *Mental and physical health*; NA = 32 for *Meaning and purpose*; NA = 49 for *Character and virtue*; NA = 28 for *Close social relationships*; NA = 27 for *Financial and material stability* subdomains.

⁴ Missing values (NA) = 3 for overall flourishing; NA = 7 for *Happiness and life satisfaction*; NA = 8 for *Mental and physical health*; NA = 14 for *Meaning and purpose*; NA = 25 for *Character and virtue*; NA = 8 for *Close social relationships*; NA = 11 for *Financial and material stability* subdomains.

⁵ Missing values (NA) = 11 for overall flourishing; NA = 15 for *Happiness and life satisfaction*; NA = 16 for *Mental and physical health*; NA = 18 for *Meaning and purpose*; NA = 24 for *Character and virtue*; NA = 20 for *Close social relationships*; NA = 16 for *Financial and material stability* subdomains.

tailed model output). Concerning farm characteristics, in three of the six domains, namely *Happiness and life satisfaction*, *Mental and physical health* and *Meaning and*

purpose, non-organic farming was associated with lower flourishing values (-0.12 , 95% CI: -0.24 – 0.00 ; -0.19 , 95% CI: -0.31 – -0.08 ; -0.24 , 95% CI: -0.39 – -0.09). The

Figure 2: Distribution frequency of the 20 pre-selected occupational hazards. The distribution of exposure frequency is presented in dark colours (1 = never exposed, 2 = rarely exposed, 3 = occasionally exposed, 4 = often exposed, 5 = always or almost always exposed). The distribution of perceived health harmfulness is displayed in light colours (1 = not harmful, 2 = somewhat harmful, 3 = rather harmful, 4 = very harmful). Missing values (NA) for each hazard (exposure & perception): heavy physical work: 6 & 11, heavy machinery: 6 & 11, heights or uneven terrain: 6 & 15, prolonged sitting: 7 & 13, fertilizers: 7 & 23, plant protection products: 8 & 31, gases or fumes: 7 & 21, strong detergents: 8 & 23, pollen or spores: 8 & 14, dust: 7 & 12, animal contact: 7 & 15, insect bites or stings: 7 & 14, conflicts: 7 & 13, sleep problems: 7 & 14, stress: 8 & 11, loneliness: 9 & 18, UV radiation: 9 & 13, heavy storms: 9 & 18, landslides: 9 & 33, noise: 10 & 19.

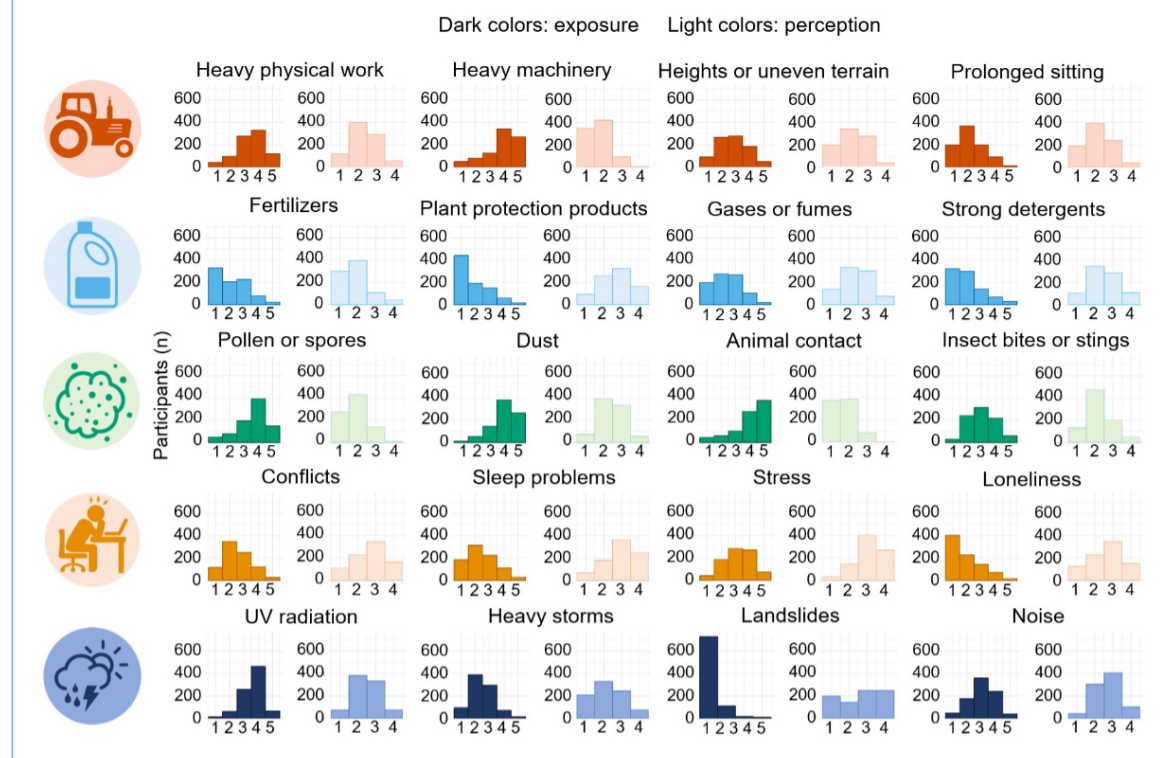
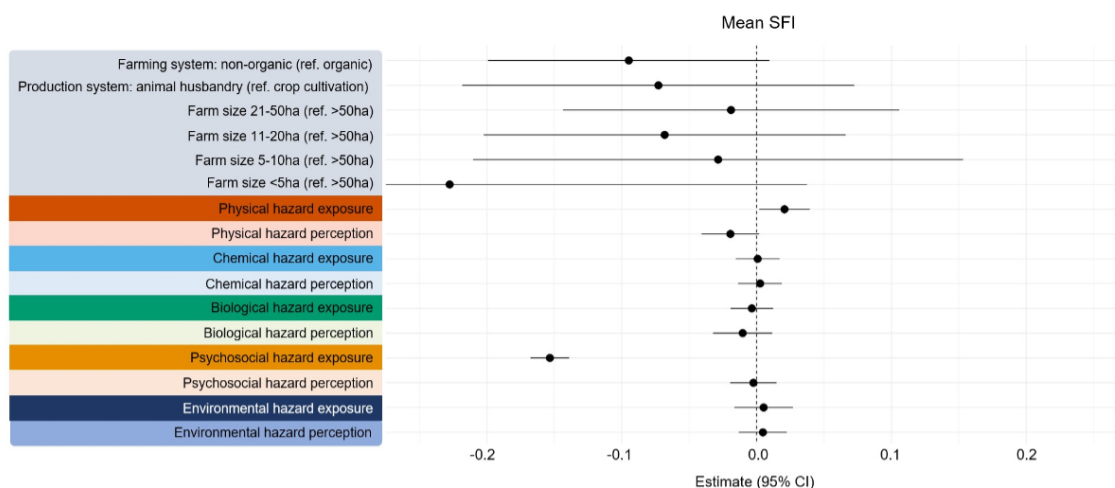


Figure 3: Results of the zero-one inflated beta regression model (logit link) depicting the association between farming system (non-organic, organic), production system (crop cultivation, animal husbandry/mixed), farm size in hectares (<5, 5–10, 11–20, 21–50, >50), exposure frequency to hazards (sum; Likert scale: 1 = never exposed, 2 = rarely exposed, 3 = occasionally exposed, 4 = often exposed, 5 = always or almost always exposed) and perceived health harmfulness of hazards (sum; Likert scale: 1 = not harmful, 2 = somewhat harmful, 3 = rather harmful, 4 = very harmful) with the mean SFI. Effect estimates of the numeric hazard domain variables represent the change in the SFI score on the logit scale as outcome variable associated with a one-unit (1 Likert point) increase in the respective hazard domain variable. For the categorical farm variables, estimates represent the SFI score change on the logit scale associated with the respective farm characteristic relative to the reference category (indicated in brackets). Bars indicate the lower and upper end of the 95% confidence interval. The model was mutually adjusted for these variables and additionally adjusted for age and sex.



same association trend was observed in the domain *Financial and material stability* (−0.14, 95% CI: −0.30–0.03). In contrast, in the domain *Close social relationships*, non-organic farming was positively associated with flourishing (0.17, 95% CI: 0.02–0.31) and there was a trend of higher flourishing in non-organic farmers in the *Character and virtue* domain (0.11, 95% CI: −0.03–0.25). A trend for lower flourishing of farmers with farms smaller than 50 ha was observed in the domains *Happiness and life satisfaction*, *Mental and physical health*, and *Financial and material stability*. In contrast, a smaller farm size of 21–50 ha and 11–20 ha was positively associated with the mean SFI in the *Close social relationships* domain (0.21, 95% CI: 0.03–0.38 and 0.20, 95% CI: 0.01–0.39).

The inverse association of exposure to psychosocial hazards with flourishing was confirmed for all SFI domains. More frequent exposure to physical hazards was positively associated with flourishing in the *Close social relationships* (0.04, 95% CI: 0.02–0.07) and the *Character and virtue* domain (0.03, 95% CI: 0.00–0.05), and the perception of physical hazards was negatively associated with the mean SFI in the domains *Mental and physical health* (−0.02, 95% CI: −0.04–0.00), *Close social relationships* (−0.03, 95% CI: −0.06–0.00) and *Financial and material stability* (−0.04, 95% CI: −0.07–0.00). Lastly, exposure

to environmental hazards was inversely associated with flourishing in the *Financial and material stability* domain (−0.05, 95% CI: −0.08–0.01), but positively associated with mean SFI values in the *Happiness and life satisfaction* domain (0.03, 95% CI: 0.01–0.06) and borderline statistically significant in the *Close social relationships* domain (0.03, 95% CI: −0.00–0.06).

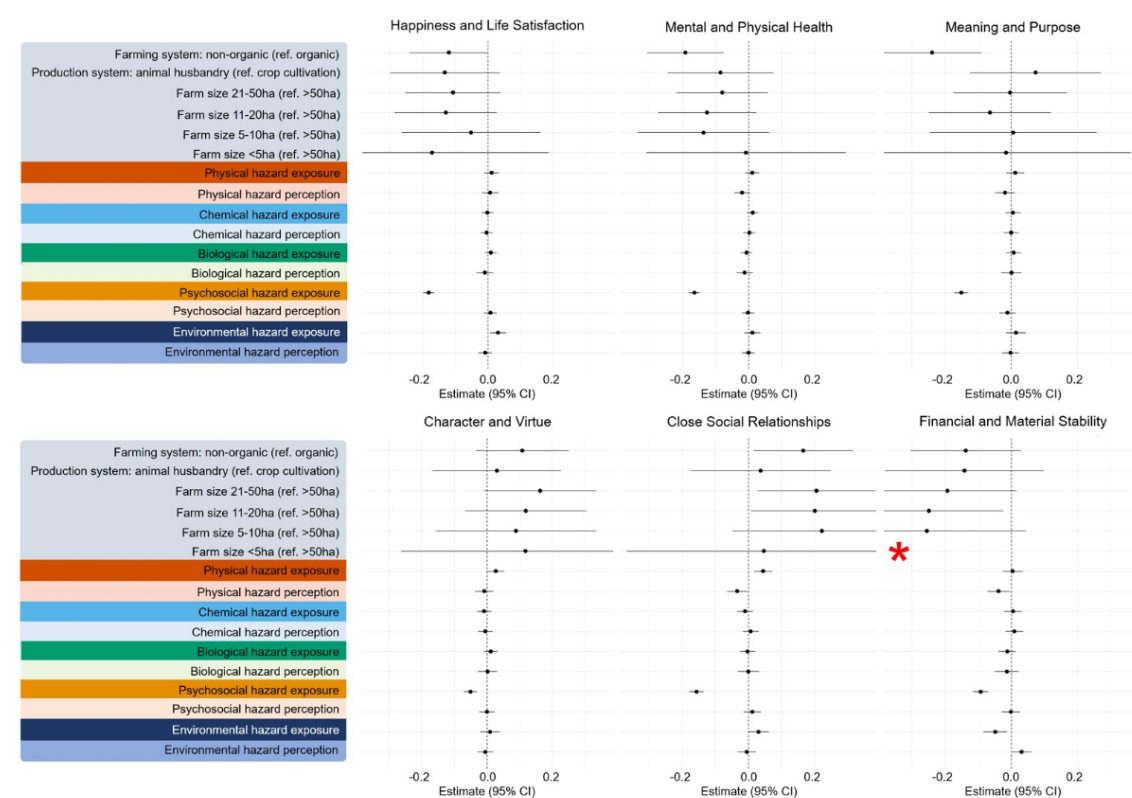
Sensitivity analysis accounting for clustering (33 clusters of size ≥ 1 , $n = 67$) at the farm level revealed no substantial changes in the reported associations of farm characteristics and hazards with the total SFI or its six subdomains (data not shown).

Discussion

Flourishing in the FarmCoSwiss and the COVCO-Basel cohorts

Results of the first agricultural cohort in Switzerland (FarmCoSwiss) revealed mean Secure Flourish Index (SFI) flourishing scores between 7 and 8. These values correspond to results of validation studies in US workplace settings and in the German general population, although measured values in the FarmCoSwiss cohort were slightly higher [39, 49]. In the Swiss context, adult participants of the population-based COVCO-Basel cohort showed sim-

Figure 4: Results of the zero-one inflated beta regression model (logit link) depicting the association between farming system (non-organic, organic), production system (animal husbandry/mixed, crop cultivation), farm size in hectares (<5, 5–10, 11–20, 21–50, >50), exposure frequency to hazards (sum; Likert scale: 1 = never exposed, 2 = rarely exposed, 3 = occasionally exposed, 4 = often exposed, 5 = always or almost always exposed) and perceived health harmfulness of hazards (sum; Likert scale: 1 = not harmful, 2 = somewhat harmful, 3 = rather harmful, 4 = very harmful) with the domain-specific mean SFI. Effect estimates of the numeric hazard domain variables represent the change in the SFI score on the logit scale as outcome variable associated with a one-unit (1 Likert point) increase in the respective hazard domain variable. For the categorical farm variables, estimates represent the SFI score change on the logit scale associated with the respective farm characteristic relative to the reference category (indicated in brackets). Bars indicate the lower and upper end of the 95% confidence interval. The model was mutually adjusted for these variables and additionally adjusted for age and sex. The red asterisk (*) indicates that the effect estimate and 95% confidence intervals lie outside the range displayed on the x-axis (−0.99, 95% CI: −1.42–0.55).



ilar flourishing values, indicating comparable levels of complete wellbeing and ability to thrive. However, our exploratory comparison between the COVCO-Basel and the FarmCoSwiss populations suggests potentially lower flourishing overall (0.26 scale points lower) and in four out of six SFI domains, namely *Happiness and life satisfaction* (0.52 points lower), *Mental and physical health* (0.65 points lower), *Close social relationships* (0.28 points lower) and *Financial and material stability* (0.27 points lower) in the farming sample. This trend held true even when comparing FarmCoSwiss participants to COVCO-Basel participants from the periurban/rural Basel-Landschaft only. There is an indication that female farmers in particular might have low flourishing scores in the *Close social relationships* and the *Financial and material stability* domains when compared to male FarmCoSwiss participants and the COVCO sample from the general population.

Although real-life implications of such differences on the SFI scale is uncertain and more research is needed to thoroughly investigate flourishing in farmers and other occupational groups in Switzerland, the observed tendency towards poorer wellbeing, particularly concerning physical and mental health, in farming communities compared to the general population aligns with findings from agricultural health research in high-income countries worldwide and Switzerland. In Australia, remote farmers specifically were found to report worse wellbeing, mental and physical health than non-farming individuals residing in remote areas [6]. Farmers often experience long working hours, leaving little time to rest or socialise [17]. With research in the USA and Ireland indicating perceived social support as a key factor influencing farmers' psychological wellbeing, social and geographical isolation may negatively impact farmers' wellbeing in comparison to the general population [50, 51]. In Norway, farmers were found to have poorer overall health, lower life satisfaction, and more physical and psychological symptoms of ill-health than skilled manual and white collar workers [52]. Studies conducted in Switzerland found elevated risks for chronic bronchitis, chronic phlegm and airway obstruction in agricultural workers as compared to the general population [53, 54]. In a UK study, farmers and their partners showed higher psychological morbidity as compared to non-farmers [55]. In Switzerland, longitudinal data from the Swiss National Cohort revealed a higher age-standardised rate of suicide in male farmers compared to non-farming male adults with an increasing trend after 2006 [56]. Furthermore, a cross-sectional study of 2017 found a higher burnout prevalence among Swiss farmers than among the general population [57].

Regarding factors influencing farmers' overall wellbeing and quality of life, scientific reviews and research conducted in the Swiss agricultural setting suggest a complex set of aspects affecting farmers' psychological wellbeing and quality of life. Frequently reported factors include work load and time pressure, economic difficulties, relational conflicts, poor physical health, and weather and climate variabilities [16, 57–59].

Occupational hazard exposure and perception

In the present study, we investigated the association between farmer's wellbeing, measured by the SFI, and 20 oc-

cupational hazards and farm-level variables. Overall, farmers semi-quantitatively reported to be most frequently exposed to biological hazards (pollen/spores, dust, direct animal contact, insect bites/stings) and least exposed to chemical hazards (fertilisers, plant protection products, gases/fumes, strong detergents). Psychosocial hazards (conflicts, sleep problems, stress, loneliness) were perceived as the most harmful and physical hazards (heavy physical work, handling heavy machinery, work in uneven terrain/at heights, prolonged sitting) as the least harmful to health. Interestingly, some hazards with low exposure frequency, such as *plant protection products* or *loneliness*, were perceived as rather harmful to health, while other hazards with the highest reported exposure, such as *handling heavy machinery* or *direct animal contact*, were perceived as least harmful to health. Although we specifically asked participants to report their subjective health hazard perception of each occupational hazard regardless of their own exposure to these hazards, it may not be straightforward to report perceived health harmfulness regardless of exposure. As such, risk research has shown that daily or regular exposure to hazards without major incidences may decrease health risk perception [60, 61]. Risk perception also tends to be lower when a hazard is viewed as controllable, such as, for example, a safe work environment [62, 63]. As risk perception refers to the perceived likelihood of negative outcomes, future studies may examine how regular exposure to and controllability of these hazards (e.g. by means of available and practicable health protection strategies) affect health hazard perception.

Flourishing and associated factors in the FarmCoSwiss cohort

Of the 20 investigated hazards, more frequent exposure to psychosocial hazards was found to be associated with lower flourishing overall and in all six subdomains. This supports previous research conducted in Switzerland identifying agriculture as a particularly stressful occupational sector with higher rates of burnout and suicide [56, 57]. Qualitative research with Swiss dairy farmers revealed that the following factors were most mentioned as reducing farmers' quality of life: always being tied to the farm/having no leisure time, financial concerns, relational conflicts, work overload and health issues [59]. Our findings further emphasise the mental health burden in the Swiss agricultural sector, which may be exacerbated by structural and behavioural barriers to seeking assistance from mental health services [64, 65]. Indeed, agricultural associations in Switzerland have launched and compiled programmes to address psychological distress and access to mental health services in the Swiss farming population [66]. For example, professionals regularly visiting farms (e.g. veterinary doctors, vendors or inspectors) were trained to better notice and assist farmers struggling with mental health, and flyers with mental health services were distributed to farmers [67, 68]. Future qualitative and mixed-methods research may assist in implementing and validating evidence-based intervention strategies to most effectively prevent and reduce mental distress among the Swiss farming population [69].

As a second finding, exposure to physical hazards (heavy physical work, handling heavy machinery, working in uneven terrain/at heights, prolonged sitting) was positively

associated with flourishing overall and in the domains *Character and virtue* and *Close social relationships*. Previous research on farmers' attitudes and identities suggests a strong work ethic of always working hard, which could be linked with higher flourishing in the *Character and virtue* domain [70].

Regarding farm-level characteristics, our results suggest slightly higher flourishing among organic farmers particularly in the domains *Happiness and life satisfaction*, *Physical and mental health* and *Meaning and purpose*, but not in the domain *Close social relationships*. These results generally feed into the existing body of literature pointing toward better wellbeing and health in organic farmers, as compared to conventional farmers. Research from France indicates that organic farmers have greater life satisfaction and higher subjective wellbeing, corresponding to our finding of higher flourishing for organic farmers in the domain *Happiness and life satisfaction* [71]. In turn, higher life satisfaction was found to be associated with higher financial compensation (income and profitability), good health, satisfaction at work and social recognition [71]. This relates to our results regarding higher flourishing of organic farmers in the *Mental and physical health* and the *Financial and material stability* domains. Systematic reviews have also reported better mental health in organic farmers or no differences between farming systems [16, 18]. Physical health has also been found to be better in organic farmers, although some symptoms and physiological indicators, such as musculoskeletal pain, respiratory symptoms or elevated diastolic blood pressure, were more prevalent in organic farmers or did not differ between farming systems [19, 72, 73]. While study participants were not asked about their income, previous research suggests that organic farming leads to higher revenues, but also coincides with higher production costs [74]. While the lack of economic incentives might hinder the transition towards organic farming, qualitative studies suggest that the non-financial benefits and values of organic agriculture, such as environmental protection or social responsibility, are more important to organic farmers [75–78], which could additionally explain higher flourishing in the *Meaning and purpose* domain. In contrast, flourishing in the domain of *Close social relationships* was higher for non-organic farmers. As roughly 83% of farms in Switzerland are non-organic, there may be more and larger local agricultural associations and networks for non-organic farmers, facilitating the establishment of social relationships. Furthermore, organic farming is generally deemed more labour-intensive, especially with regard to crop cultivation [79]. Therefore, the additional labour required might lead to more conflicts and less time for fostering social relationships. Similarly, in the same SFI domain, a higher work load and more working hours may also explain our finding of lower flourishing of farmers with farms larger than 50 ha.

While the association between flourishing and the farming system observed in the present study had effect estimates between 0.1 and 0.2 scale points, the most pronounced effect size in our analysis was observed in the *Financial and material stability* domain for small farms (<5 ha), which was, on average, associated with a decrease in mean SFI (logit scale) of 1 as compared to the largest farms (>50

ha). This finding may relate to the structural change in the last two decades in Switzerland and Europe towards fewer farms and greater cultivated areas per farm [80, 81]. Hence, smaller farms with a generally lower productivity may increasingly experience financial struggles, especially since direct payments in Switzerland are linked to farm size [40, 82].

Strengths and limitations

Investigating, maintaining and promoting farmers' health and wellbeing is essential to ensure nutrition and food security. In Switzerland, no national agricultural health cohort has been established so far. Therefore, there is little evidence on the physical and mental health, overall wellbeing and flourishing or on their predictive determinants among Swiss farmers. As the first national agricultural cohort, FarmCoSwiss offers the opportunity to examine Swiss farmers' health, wellbeing and concerns and their temporal development over the coming years in a period of climate change and increasing food insecurity [83]. The present study is the first to investigate the holistic concept of human flourishing in a sample of 872 Swiss farmers and to put it into the perspective of exposure to, and perception of, a broad range of occupational health hazards that the farming community is exposed to. Therefore, the results of this study can assist in setting priorities for subsequent agricultural health research in Switzerland.

Despite the insights gained, a few limitations of our study have to be addressed. First, the strong association between lower flourishing and exposure to psychosocial hazards (*conflicts, sleep problems, stress, and loneliness*) might potentially be due to circularity, as the flourishing scale measures components of mental health and satisfaction with social relationships, which are linked to the four pre-selected psychosocial hazards in our hazard matrix [33]. Yet, it is of interest to note that psychosocial hazards were associated with SFI in all subdomains.

Second, participants were required to answer each question in the online questionnaire to reduce missing values. However, some participants completed the survey on paper or terminated the questionnaire early, introducing missing values in relevant variables. As missing values were below 5% for all variables of interest, we did not use imputation methods and did not conduct a complete case analysis in order to maintain sample size. Yet, due to the small number of missing values, introduction of bias is unlikely.

Third, the exploratory comparison of mean SFI values between the FarmCoSwiss and the COVCO cohort should be interpreted with caution, as the aims of the two cohorts were inherently different. While we specifically used flourishing data from the COVCO cohort collected in the follow-up 2023 survey to match the time of data collection between the two cohorts and to reduce short-term COVID-19 pandemic-related effects on flourishing, it cannot be ruled out that selection and/or attrition biases affect the comparison.

Fourth, in the absence of access to a national registry of the agricultural workforce, we could not use stratified or cluster randomised sampling strategies to ensure representativeness and generalisability. Given generally low participation rates in epidemiological studies, even popula-

tion-based sampling does not guarantee representativeness [84]. Furthermore, the main aim of setting up a cohort is to minimise loss to follow-up, not to achieve representativeness. We nevertheless made efforts to increase representativeness by using different channels to promote our study (e.g. non-organic and organic agricultural associations, fruit production and animal husbandry organisations, or female farmer associations). Representativeness and generalisability of our study results remain a limitation for prevalence estimates regarding flourishing and hazards, also in the light of potential healthy worker effect. Our sample consists of slightly more organic farmers (Switzerland: 16% of farms, our sample: 22%), more farms with animal husbandry (Switzerland: 67%, our sample: 88%), fewer smaller (0–10 ha) farms (Switzerland: 28%, our sample: 11%) and more larger (20–50 ha) farms (Switzerland: 38%, our sample: 47%) [80]. Generalising the differences in flourishing between FarmCoSwiss and COVCO-Basel to those between Swiss farmers and the general population of Switzerland is not possible given that neither of the two studies are truly representative.

Lastly, more vulnerable groups, such as migrant workers and employed farm workers, are currently underrepresented in the cohort. With regard to sex, one third of our sample are women, a similar value to the 36% women employed in Swiss agriculture [85]. In contrast to prevalence estimates, which may not be generalisable, the observed associations of flourishing with farm characteristics and hazard exposure or perception are only biased if participation in our study is differential.

Conclusion

In conclusion, this cohort study provides valuable insights into farmers' wellbeing in Switzerland. The findings highlight the burden of psychological distress in Swiss farming communities and the association between exposure to psychosocial hazards and decreased flourishing. Our results further suggest that non-organic and organic farmers, as well as farms of different sizes, face different occupational pressures that may affect human flourishing. Further studies are warranted to investigate the wellbeing of specific subgroups, e.g. women and migrant workers, and to identify occupational hazards and farm-level characteristics most relevant to farmers' wellbeing. Qualitative and mixed-method approaches can additionally aid in designing adequate mental health strategies for the Swiss farming population and specific farm settings.

Overall, this study contributes to the growing body of evidence on occupational health epidemiology in agriculture and sets the stage for investigating the longitudinal development of farmers' wellbeing in Switzerland. Ultimately, this evidence may be used to better and more inclusively inform agricultural and public health policy decisions.

Data availability statement

The data supporting the findings of this study is not openly available due to its sensitive nature and is available from the corresponding author upon reasonable request and under a data use agreement only. Data is located in controlled access data storage at the Swiss Tropical and Public Health Institute.

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Potential competing interests

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflict of interest related to the content of this manuscript was disclosed.

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Appendix

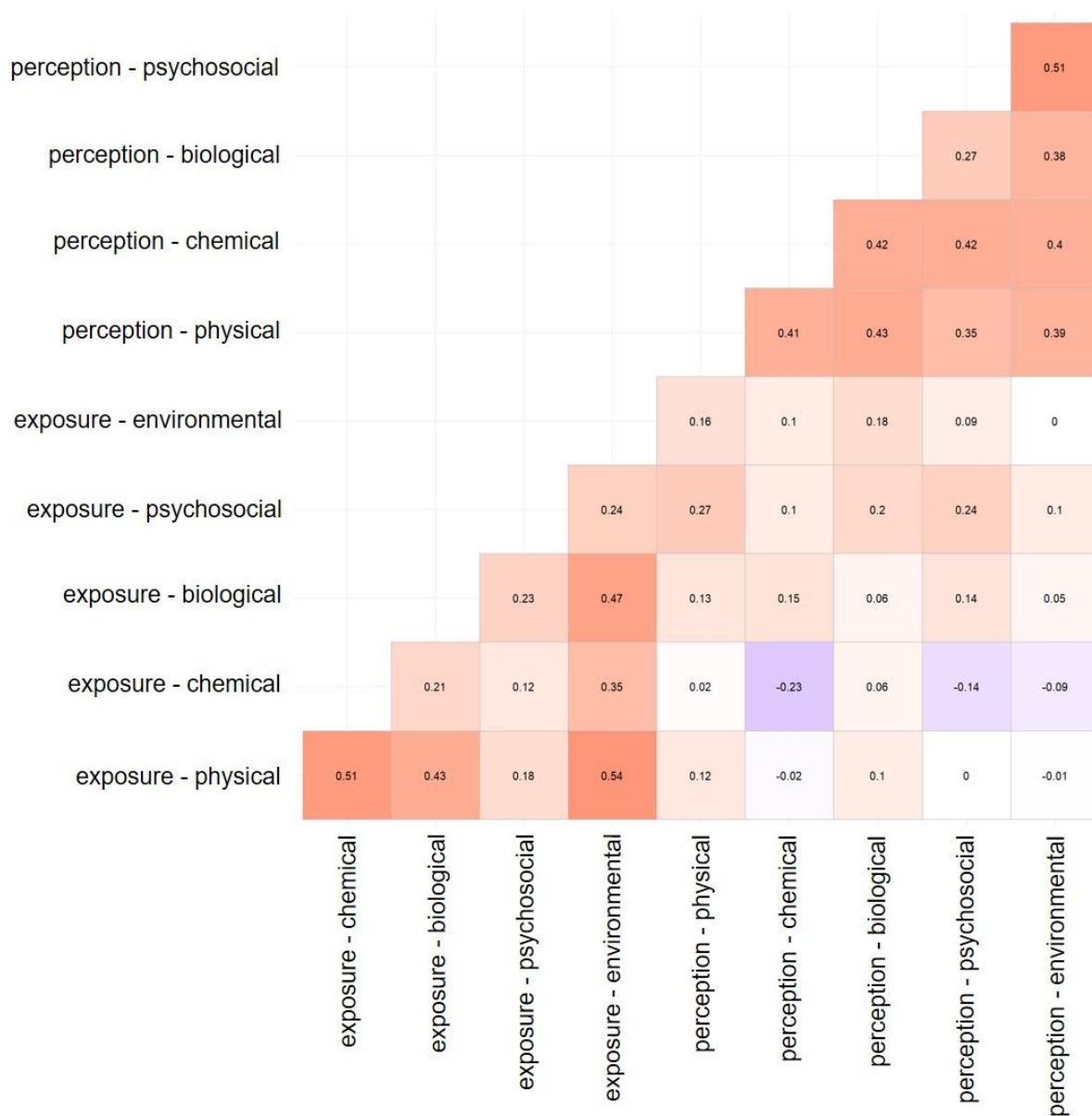


Figure S1 Spearman Correlation Matrix Hazard Domains.

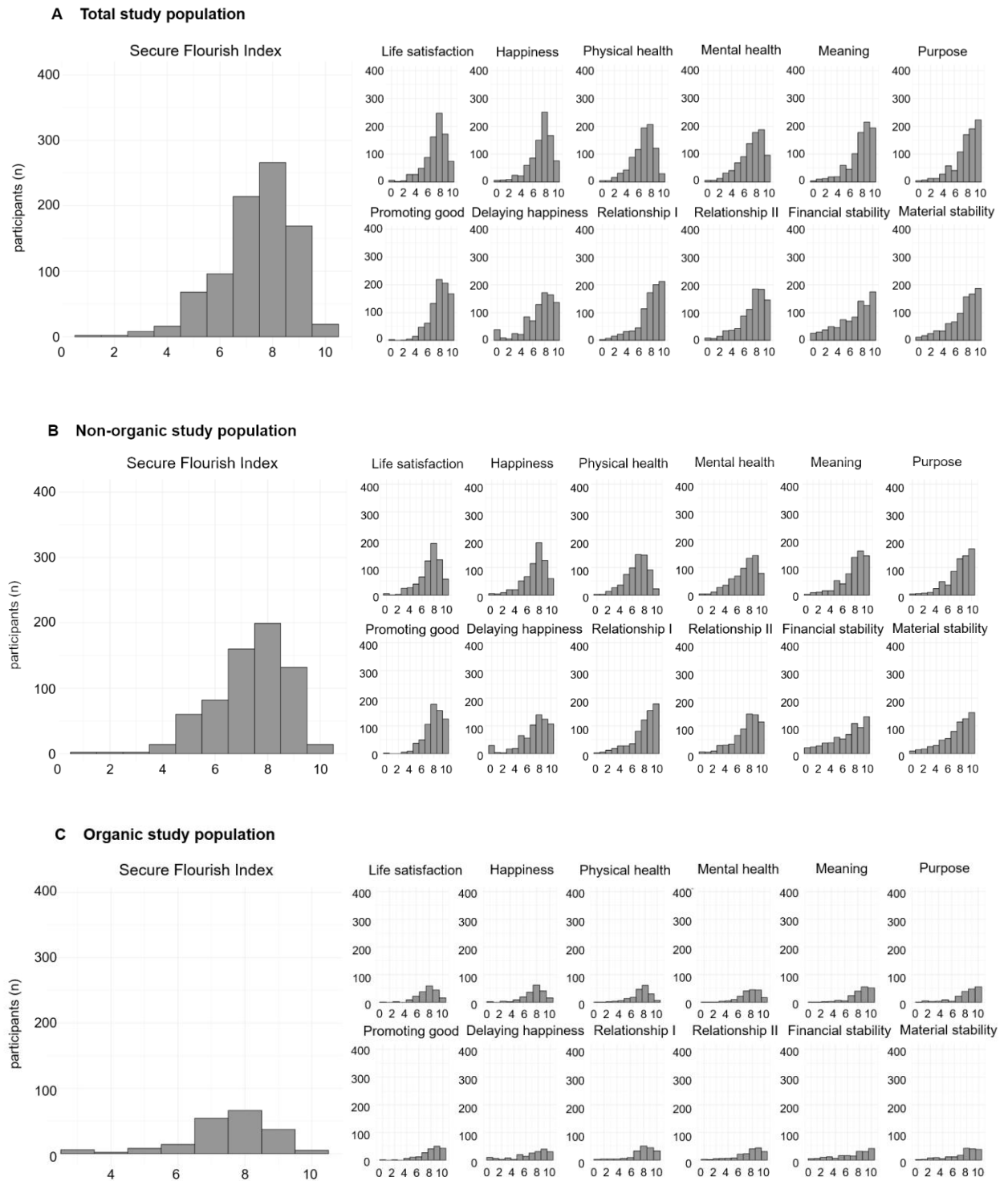


Figure S2 Frequency distribution of the total secure flourish index and the 12 instrument items (0 = low flourishing, 10 = high flourishing) for the total study population (A, n = 872), non-organic farmers (B, n = 675), and organic farmers (C, n = 195). A total of two participants could not be allocated to a non-organic or organic farming system (NA).

Table S1 Mean overall and domain-specific Secure Flourish Index among FarmCoSwiss and COVCO-Basel cohort participants, stratified by canton (COVCO-Basel), sex (both cohorts), and age categories (both cohorts).

	FarmCoSwiss		COVCO-Basel		Basel-Stadt (urban)		Basel- Landschaft (rural)	
Participants (total), n (%)	872 (100)		7'220 (100)		3'582 (49.7)		3'638 (50.3)	
Sex	m	w	m	w	m	w	m	w
Participants, n (%)	575 (65.9)	297 (34.1)	3'198 (44.3)	4'022 (55.7)	1'582 (44.2)	2'000 (55.8)	1.616 (44.4)	2'022 (55.6)
SFI, mean ($\pm$ SD)¹								
Overall SFI	7.48 (1.46)	7.37 (1.31)	7.74 (1.28)	7.65 (1.32)	7.63 (1.32)	7.62 (1.37)	7.85 (1.24)	7.72 (1.26)
Happiness and life satisfaction	7.39 (1.87)	7.40 (1.67)	7.95 (1.54)	7.89 (1.56)	7.84 (1.56)	7.85 (1.60)	8.05 (1.52)	7.93 (1.52)
Mental and physical health	7.05 (1.80)	7.00 (1.58)	7.73 (1.48)	7.65 (1.53)	7.66 (1.49)	7.62 (1.57)	7.80 (1.47)	7.67 (1.49)
Meaning and purpose	7.90 (1.94)	7.88 (1.83)	7.84 (1.81)	7.80 (1.81)	7.68 (1.85)	7.71 (1.89)	8.00 (1.75)	7.89 (1.71)
Character and virtue	7.61 (1.70)	7.57 (1.68)	7.61 (1.59)	7.48 (1.67)	7.56 (1.57)	7.39 (1.70)	7.65 (1.60)	7.57 (1.62)
Close social relationships	7.71 (2.11)	7.57 (2.02)	7.87 (1.71)	7.99 (1.73)	7.76 (1.76)	7.94 (1.76)	7.98 (1.67)	8.04 (1.70)
Financial and material stability	7.19 (2.48)	6.83 (2.37)	7.47 (2.69)	7.23 (2.68)	7.33 (2.76)	7.19 (2.74)	7.61 (2.61)	7.26 (2.63)
Age	<50	≥ 50	<50	≥ 50	<50	≥ 50	<50	≥ 50
Participants, n (%)	443 (50.8)	429 (49.2)	1'368 (18.9)	5'852 (81.1)	727 (20.3)	2'855 (79.7)	641 (17.6)	2'997 (82.4)

SFI, mean ($\pm$ SD)								
Overall SFI	7.32 (1.40)	7.56 (1.41)	7.26 (1.31)	7.81 (1.28)	7.17 (1.35)	7.74 (1.32)	7.36 (1.25)	7.87 (1.24)
Happiness and life satisfaction	7.26 (1.83)	7.53 (1.76)	7.45 (1.61)	8.02 (1.52)	7.39 (1.66)	7.96 (1.55)	7.51 (1.57)	8.08 (1.49)
Mental and physical health	7.04 (1.68)	7.02 (1.78)	7.29 (1.55)	7.78 (1.49)	7.24 (1.60)	7.74 (1.51)	7.36 (1.49)	7.81 (1.47)
Meaning and purpose	7.74 (1.96)	8.05 (1.84)	7.23 (1.93)	7.95 (1.75)	7.05 (2.04)	7.86 (1.80)	7.45 (1.78)	8.04 (1.70)
Character and virtue	7.57 (1.70)	7.63 (1.68)	7.60 (1.46)	7.52 (1.67)	7.49 (1.53)	7.46 (1.68)	7.73 (1.36)	7.58 (1.66)
Close social relationships	7.55 (2.14)	7.77 (2.02)	7.61 (1.77)	8.02 (1.71)	7.53 (1.78)	7.95 (1.75)	7.70 (1.76)	8.08 (1.66)
Financial and material stability	6.74 (2.38)	7.40 (2.48)	6.37 (2.98)	7.56 (2.57)	6.30 (3.05)	7.50 (2.62)	6.44 (2.90)	7.62 (2.52)

¹ SFI: Secure Flourish Index; SD: standard deviation

Table S2 Occupational hazards, self-assessed by participants with regard to exposure frequency and perceived health harmfulness, stratified by farming system. Highest values per domain are marked in bold.

Hazards	Exposure frequency ¹						Perception of health harmfulness ²					
	Total		Non-organic		Organic		Total		Non-organic		Organic	
	(n = 112)		(n = 100)		(n = 100)		(n = 112)		(n = 100)		(n = 100)	
	Mean	SD ³	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Heavy physical work	3.45	1.01	3.39	1.04	3.64	0.90	2.32	0.78	2.34	0.79	2.21	0.74
Handling heavy machinery	3.12	1.13	3.12	1.14	3.11	1.11	1.70	0.66	1.65	0.64	1.88	0.69
Work at height/in uneven terrain	2.81	1.06	2.76	1.07	3.02	1.00	2.17	0.83	2.18	0.84	2.16	0.82
Prolonged sitting	2.24	0.95	2.21	0.95	2.32	0.96	2.14	0.80	2.11	0.81	2.27	0.76
Fertilizers	2.14	1.10	2.29	1.11	1.61	0.91	1.87	0.81	1.78	0.73	2.19	0.99
Plant protection products	1.86	1.06	2.05	1.08	1.22	0.64	2.11	0.91	2.11	0.86	3.11	1.00
Gases/Fumes	2.31	1.03	2.44	1.03	2.11	0.99	2.37	0.85	2.33	0.85	2.51	0.85
Strong detergents	2.04	1.07	2.14	1.10	1.70	0.90	2.46	0.87	2.43	0.84	2.59	0.93
Pollen/Spores	3.59	1.05	3.56	1.03	3.70	1.11	1.86	0.72	1.85	0.72	1.91	0.71
Dust	3.96	0.93	3.93	0.94	4.08	0.89	2.43	0.74	2.41	0.74	2.13	0.74
Animal contact/Animal excretions	4.12	1.13	4.11	1.15	4.11	1.06	1.66	0.67	1.67	0.67	1.65	0.67
Insect bites/stings	3.04	0.97	2.99	0.97	3.23	0.94	2.20	0.76	2.22	0.76	2.13	0.75

Conflicts	2.52	0.99	2.53	0.99	2.50	0.96	2.65	0.93	2.63	0.93	2.73	0.93
Sleep problems	2.40	1.05	2.40	1.05	2.42	1.07	2.92	0.89	2.90	0.90	2.98	0.86
Stress	3.1	1.02	3.1	1.04	3.1	0.94	3.0	0.79	3.0	0.79	3.04	0.78
Loneliness	1.91	1.06	1.92	1.07	1.88	1.02	2.62	0.94	2.61	0.94	2.66	0.93
UV radiation	3.0	0.78	3.02	0.79	3.0	0.69	2.47	0.76	2.47	0.76	2.46	0.75
Heavy storms	2.44	0.84	2.42	0.86	2.52	0.79	2.21	0.90	2.23	0.92	2.14	0.84
Landslides/Avalanches	1.18	0.47	1.17	0.46	1.22	0.52	2.64	1.14	2.64	1.13	2.04	1.18
Noise	3.05	0.93	3.04	0.94	3.11	0.89	2.0	0.74	2.0	0.75	2.04	0.70
Domains												
Physical hazards	3.08	0.72	3.04	0.73	3.20	0.66	2.09	0.55	2.07	0.56	2.14	0.50
Chemical hazards	2.11	0.80	2.23	0.81	1.68	0.58	2.33	0.70	2.27	0.67	2.55	0.78
Biological hazards	3.0	0.78	3.02	0.79	3.0	0.76	2.04	0.52	2.04	0.52	2.06	0.51
Psychosocial hazards	2.50	0.77	2.51	0.77	2.49	0.74	2.01	0.72	2.01	0.72	2.0	0.72
Environmental hazards	2.56	0.54	2.54	0.55	2.67	0.48	2.49	0.66	2.50	0.67	2.46	0.62

¹ Likert scale: 1 = never exposed, 2 = rarely exposed, 3 = occasionally exposed, 4 = often exposed, 5 = (almost) always exposed

² Likert scale: 1 = not harmful, 2 = somewhat harmful, 3 = rather harmful, 4 = very harmful

³ SD: standard deviation

Table S3 Beta regression analysis results examining the association of farm variables, exposure frequency to hazards, and perceived health harmfulness of hazards with the mean Secure Flourish Index. The model was additionally adjusted for age and sex. *P*-values below 0.2 are marked in bold.

Variable	estimate	SD ¹	<i>p</i> -value	CI ¹
Farming system ²	-0.094	0.053	0.000	-0.199, 0.009
Production system ³	-0.072	0.074	0.326	-0.218, 0.072
Farm size (21-50) ⁴	-0.018	0.063	0.765	-0.143, 0.105
Farm size (11-20)	-0.068	0.068	0.319	-0.202, 0.066
Farm size (5-10)	-0.028	0.092	0.758	-0.210, 0.153
Farm size (<5)	-0.227	0.135	0.002	-0.492, 0.037
Physical hazards – exposure	0.020	0.009	0.031	0.001, 0.039
Chemical hazards – exposure	0.001	0.008	0.920	-0.015, 0.017
Biological hazards – exposure	-0.003	0.008	0.664	-0.019, 0.012
Psychosocial hazards – exposure	-0.153	0.007	0.000	-0.167, -0.139
Environmental hazards – exposure	0.005	0.011	0.636	-0.016, 0.026
Physical hazards – perception	-0.019	0.010	0.004	-0.040, 0.001
Chemical hazards – perception	0.002	0.008	0.753	-0.013, 0.018
Biological hazards – perception	-0.010	0.011	0.356	-0.032, 0.011
Psychosocial hazards – perception	-0.002	0.008	0.784	-0.019, 0.014
Environmental hazards – perception	0.004	0.009	0.607	-0.013, 0.022

¹SD: standard deviation; 95% CI: 95% confidence interval

² non-organic, reference category organic

³ animal husbandry/mixed, reference category crop cultivation

⁴ categorical variable ([hectares]), reference category >50

Model: *avg_sfi ~ farming_system + production_system + farm_size + physical_frequency + chemical_frequency + biological_frequency + psychosocial_frequency + environmental_frequency + physical_perception + chemical_perception + biological_perception + psychosocial_perception + environmental_perception + age + sex*

Table S4 Beta regression analysis results examining the association of the farming system, exposure frequency to hazards, and perceived health harmfulness of hazards with the domain-specific mean Secure Flourish Index. The models were additionally adjusted for age and sex. *P*-values below 0.2 are marked in bold.

Variable	β estimate	SD ¹	<i>p</i> -value	95% CI ¹
Healthiness and life satisfaction				
Farming system ²	-0.120	0.061	0.034	-0.240, 0.000
Production system ³	-0.132	0.085	0.121	-0.299, 0.035
Farm size (21-50) ⁴	-0.107	0.074	0.100	-0.253, 0.039
Farm size (11-20)	-0.129	0.079	0.100	-0.285, 0.027
Farm size (5-10)	-0.052	0.108	0.629	-0.264, 0.159
Farm size (<5)	-0.171	0.182	0.346	-0.528, 0.185
Physical hazards – exposure	0.010	0.011	0.332	-0.011, 0.032
Chemical hazards – exposure	-0.001	0.009	0.854	-0.020, 0.017
Biological hazards – exposure	0.008	0.009	0.383	-0.010, 0.026
Psychosocial hazards – exposure	-0.181	0.008	0.000	-0.198, -0.164
Environmental hazards – exposure	0.030	0.012	0.010	0.005, 0.056
Physical hazards – perception	0.006	0.012	0.615	-0.018, 0.030
Chemical hazards – perception	-0.004	0.009	0.635	-0.023, 0.014
Biological hazards – perception	-0.009	0.013	0.455	-0.035, 0.015
Psychosocial hazards – perception	0.007	0.010	0.485	-0.013, 0.027
Environmental hazards – perception	-0.008	0.010	0.415	-0.029, 0.012
Mental and physical health				
Farming system ²	-0.191	0.059	0.001	-0.307, -0.075
Production system ³	-0.085	0.081	0.293	-0.244, 0.074
Farm size (21-50) ⁴	-0.080	0.070	0.252	-0.217, 0.057

Farm size (11-20)	-0.125	0.075	□.□□□	-0.274, 0.022
Farm size (5-10)	-0.136	0.101	□.1□□	-0.334, 0.062
Farm size (<5)	-0.008	0.153	0.955	-0.309, 0.292
Physical hazards – exposure	0.010	0.010	0.334	-0.010, 0.031
Chemical hazards – exposure	0.011	0.009	0.201	-0.006, 0.029
Biological hazards – exposure	-0.007	0.008	0.425	-0.024, 0.010
Psychosocial hazards – exposure	-0.164	0.008	□.□□□	-0.180, -0.148
Environmental hazards – exposure	0.010	0.012	0.376	-0.013, 0.035
Physical hazards – perception	-0.020	0.012	□.□□□	-0.043, 0.003
Chemical hazards – perception	0.001	0.009	0.854	-0.016, 0.019
Biological hazards – perception	-0.012	0.012	0.319	-0.037, 0.012
Psychosocial hazards – perception	-0.002	0.009	0.806	-0.021, 0.016
Environmental hazards – perception	-0.000	0.009	0.938	-0.020, 0.01

Meaning and Purpose

Farming system ²	-0.239	0.076	□.□□1	-0.378, -0.088
Production system ³	0.073	0.100	0.466	-0.124, 0.271
Farm size (21-50) ⁴	-0.003	0.087	0.968	-0.175, 0.168
Farm size (11-20)	-0.064	0.094	0.493	-0.249, 0.120
Farm size (5-10)	0.006	0.128	0.961	-0.245, 0.258
Farm size (<5)	-0.015	0.191	0.935	0.391, 0.360
Physical hazards – exposure	0.012	0.013	0.384	-0.015, 0.039
Chemical hazards – exposure	0.004	0.011	0.675	-0.018, 0.028
Biological hazards – exposure	0.007	0.011	0.503	-0.014, 0.029
Psychosocial hazards – exposure	-0.150	0.010	□.□□□	-0.171, -0.130
Environmental hazards – exposure	0.014	0.015	0.350	-0.015, 0.044

Physical hazards – perception	-0.018	0.015	0.215	-0.048, 0.011
Chemical hazards – perception	-0.000	0.011	0.996	-0.023, 0.023
Biological hazards – perception	0.000	0.015	0.949	-0.029, 0.031
Psychosocial hazards – perception	-0.011	0.012	0.366	-0.036, 0.013
Environmental hazards – perception	-0.002	0.013	0.872	-0.027, 0.023

Character and virtue

Farming system ²	0.107	0.072	□ 134	-0.033, 0.248
Production system ³	0.029	0.100	0.767	-0.166, 0.226
Farm size (21-50) ⁴	0.161	0.087	□□ 4	-0.010, 0.333
Farm size (11-20)	0.118	0.094	0.209	-0.066, 0.303
Farm size (5-10)	0.088	0.125	0.479	-0.156, 0.333
Farm size (<5)	0.117	0.193	0.545	-0.262, 0.497
Physical hazards – exposure	0.026	0.013	□ 4 □	0.000, 0.053
Chemical hazards – exposure	-0.009	0.011	0.432	-0.031, 0.013
Biological hazards – exposure	0.010	0.010	0.319	-0.010, 0.032
Psychosocial hazards – exposure	-0.050	0.009	□□□□	-0.070, -0.030
Environmental hazards – exposure	0.008	0.015	0.553	-0.020, 0.038
Physical hazards – perception	-0.008	0.014	0.564	-0.037, 0.020
Chemical hazards – perception	-0.005	0.011	0.641	-0.027, 0.016
Biological hazards – perception	0.001	0.015	0.916	-0.028, 0.031
Psychosocial hazards – perception	-0.000	0.012	0.988	-0.023, 0.023
Environmental hazards – perception	-0.005	0.012	0.675	-0.029, 0.019

Close social relationships

Farming system ²	0.165	0.076	□ 3 □	0.016, 0.314
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Production system ³	0.036	0.108	0.735	-0.175, 0.248
Farm size (21-50) ⁴	0.205	0.090	□.□ 23	0.027, 0.382
Farm size (11-20)	0.200	0.098	□.□ 41	0.007, 0.392
Farm size (5-10)	0.220	0.136	□.1□□	-0.047, 0.488
Farm size (<5)	0.046	0.210	0.825	-0.366, 0.459
Physical hazards – exposure	0.044	0.014	□.□□ 1	0.016, 0.072
Chemical hazards – exposure	-0.009	0.012	0.418	-0.033, 0.013
Biological hazards – exposure	-0.002	0.011	0.834	-0.025, 0.020
Psychosocial hazards – exposure	-0.156	0.010	□.□□□	-0.177, -0.134
Environmental hazards – exposure	0.030	0.015	□.□□□	-0.000, 0.061
Physical hazards – perception	-0.033	0.015	□.□ 32	-0.064, -0.002
Chemical hazards – perception	0.007	0.012	0.568	-0.017, 0.031
Biological hazards – perception	-0.000	0.016	0.990	-0.032, 0.032
Psychosocial hazards – perception	0.011	0.013	0.376	-0.014, 0.037
Environmental hazards – perception	-0.004	0.013	0.731	-0.031, 0.022

Financial and material stability

Farming system ²	-0.137	0.084	□.1□ 3	-0.303, 0.028
Production system ³	-0.141	0.121	0.244	-0.380, 0.097
Farm size (21-50) ⁴	-0.192	0.106	□.□□□	-0.402, 0.016
Farm size (11-20)	-0.248	0.114	□.□ 2 □	-0.472, -0.024
Farm size (5-10)	-0.255	0.151	□.□□ 3	-0.552, 0.042
Farm size (<5)	-0.987	0.221	□.□□□	-1.422, -0.553
Physical hazards – exposure	0.003	0.015	0.823	-0.026, 0.033
Chemical hazards – exposure	0.004	0.013	0.738	-0.021, 0.030
Biological hazards – exposure	-0.012	0.013	0.341	-0.038, 0.013
Psychosocial hazards – exposure	-0.092	0.011	□.□□□	-0.116, -0.069

Environmental hazards – exposure	-0.048	0.017	□□□□	-0.083, -0.013
Physical hazards – perception	-0.038	0.017	□□2□	-0.073, -0.004
Chemical hazards – perception	0.008	0.013	0.519	-0.017, 0.035
Biological hazards – perception	-0.013	0.018	0.446	-0.049, 0.021
Psychosocial hazards – perception	-0.001	0.014	0.904	-0.029, 0.026
Environmental hazards – perception	0.030	0.014	□□3□	0.001, 0.059

¹SD: standard deviation; 95% CI: 95% confidence interval

² non-organic, reference category organic

³ animal husbandry/mixed, reference category crop cultivation

⁴ categorical variable ([hectares]), reference category >50

Model: *sfi_domain* ~ *farming_system* + *production system* + *farm size* + *physical_frequency* + *chemical_frequency* + *biological_frequency* + *psychosocial_frequency* + *environmental_frequency* + *physical_perception* + *chemical_perception* + *biological_perception* + *psychosocial_perception* + *environmental_perception* + *age* + *sex*