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# Community factors associated with stunting, overweight and food insecurity: a community-based mixed-method study in four Andean indigenous communities in Ecuador

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## ABSTRACT

**Objectives** We aimed to implement participatory research to answer a question posed by four Kichwa indigenous communities in Andean Ecuador about what actionable factors are associated with childhood stunting, overweight and food insecurity among their people.

**Design** We used mixed methods including household questionnaires, discussion groups with respondents of the questionnaires and anthropometric measurement of children (6 months to 12 years) from surveyed households.

**Setting** The study involved four Andean indigenous communities transitioning from traditional to Western lifestyles. They subsist mainly on small-scale agriculture and have a rich cultural heritage including their traditional language.

**Participants** Anthropometric data were collected from 298 children from 139 households in four communities; all households completed the questionnaire. We held five discussion groups (6–10 participants each): three composed of mothers and two of farmers.

**Primary and secondary outcome measures** Primary outcomes were stunting, overweight, food insecurity and their relationship with demographics, dietary habits and agricultural habits.

**Results** Of 298 children, 48.6% were stunted and 43.3% overweight for age. Stunted children were more likely to live in households that sold livestock (ORa 1.77, 95% Cla 1.06 to 2.95) and with illiterate primary caretakers (ORa 1.81, 95% Cla 1.07 to 3.06), but were less likely to live in households with irrigation (ORa 0.47, 95% Cla 0.27 to 0.81). Overweight children were more likely to be male (ORa 1.87, 95% Cla 1.02 to 3.43) and live in a household that sold livestock (ORa 2.14, 95% Cla 1.14 to 4.02). Some 67.8% of children lived in a household with food insecurity, more frequently in those earning below minimum wage (ORa 2.90, 95% Cla 1.56 to 5.41) and less frequently in those that ate quinoa in the past 24 hours (ORa 0.17, 95% Cla 0.06 to 0.48). Discussion groups identified irrigation and loss of agricultural and dietary traditions as important causes of poor childhood nutrition.

**Conclusion** Many indigenous communities face tumultuous cultural, nutritional and epidemiological transitions. Community-based interventions on factors identified here could mitigate negative health outcomes.

## Strengths and limitations of this study

- Participating communities initiated the research and defined the research question.
- We combined quantitative measurement (including anthropometry) with qualitative group discussions.
- Data collection in the local language relied on local community members fluent in Kichwa and Spanish.
- The small size of participating communities limited statistical power in quantitative analysis.
- 24 hours dietary histories provided only a limited snapshot of food habits.

## INTRODUCTION

Ecuador is a geographically and ethnically diverse country, with 14 indigenous groups representing 7% of the total population (approximately 1 million individuals).[1] The Andean Kichwa are one of the largest indigenous groups in the country.[2] Among indigenous communities, some 42% children under 5 years of age are stunted compared with 18%–24% of their non-indigenous counterparts.[2 3] However, this proportion varies between populations in the Andean mountains, the Pacific coast and the Amazon region.[4] Direct causes of malnutrition (and resulting stunting) are inadequate caloric intake and high burden of disease, but there are complex social factors that predispose a child to stunting including maternal education, socioeconomic status and income.[5] Factors related to poor nutritional status have been studied in the Amazonian indigenous populations of Ecuador,[6] but the evidence is less clear for the Andean indigenous populations,[7] where there are additional physiological and agricultural stresses related to living at high altitude.[8]

Multiple factors affect a child's risk of malnutrition, and there are many consequences to being malnourished. Malnutrition (defined as poor anthropomorphic measures) could underlie as much as 50% of early childhood mortality, and has been found to be associated specifically with increased mortality rate of diarrhoea and acute respiratory illness.[9] Additional consequences of malnutrition include shorter adult height, less schooling (possibly related to duration of childhood illnesses) and reduced economic productivity.[10] Because of their smaller stature, children who grow up with malnutrition are at a greater risk of being overweight (weight related to height) as adults[11]; this trend is visible throughout Latin America with increasing rates of overweight.

Recent evidence indicates that the prevalence of overweight is related to nutritional and epidemiological transitions associated with market integration, defined here as the degree of production for and consumption from a market-based economy, whereby communities have increased participation in and dependence on markets for food resources.[12–14] This integration can change diet and physical activity,[2] shifting from a diet of traditional grains and hunter-gatherer lifestyle to a diet of processed foods high in fats and sugars and sedentary lifestyle.[14 15] Frequently, an epidemiological transition follows the nutritional transition, with infectious and maternal/perinatal diseases being replaced by cardiovascular and metabolic diseases.[16] There is some evidence for this trend in indigenous populations of Amazonian Ecuador, where changes in body size, cholesterol level and blood pressure have been documented in relation to degree of market integration.[12 17] The healthcare system in Ecuador is not prepared to deal with this dual burden of stunting and obesity (and the diseases associated with each)[18] and its costs, both in terms of morbidity/mortality and financial.[12 19]

The Training and Education for Andean Community Health (TEACH) programme is a partnership between the McGill University Department of Family Medicine and the participating indigenous communities that strives to improve health via training community health workers (CHW). In this context, this study is a collaboration with four communities that asked for assistance to research nutrition and agriculture, with a view towards community action to address their health concerns. Our objective was to implement a participatory approach to identify the factors associated with childhood stunting, overweight and food insecurity among four Kichwa Andean indigenous communities.[20] We hypothesised that most of these factors were associated with cultural transition towards a Western lifestyle.

## METHODS

We conducted the study during July and August of 2013 and 2014 in four communities (Chilcapamba, Morales Chupa, Iltaqui and Arrayanes) in Ecuador (Northern Andes), between 5 and 15 km from Cotacachi, where the nearest market and hospital are located. As indigenous subsistence farming communities, agriculture faces the challenges of rugged and mountainous terrain and seasonally dry climate (average yearly rainfall 906 mm).[21] Typical crops grown by these communities include corn, peas, beans and potatoes. Typical livestock raised are chickens and guinea pigs which are used to feed the household. Some households also raise pigs or cows, mainly to be sold at a community market.

The mixed-method approach included three components: (1) discussion groups with farmers and mothers, (2) questionnaires administered to all households without sampling and (3) anthropometric measurement of children without sampling. We collaborated with the CHW as an intercultural team to adjust research instruments that capture the local context and promote engagement of participants in the project. The CHW decided the research topic (ie, childhood malnutrition, stunting and agriculture) with input from their four communities. Together with the CHW, the researchers identified three related outcomes: childhood overweight, stunting and food insecurity, as core indicators of nutritional state. We then specified factors potentially related to those outcomes including household demographics, productive activities, sales of crops and livestock, and food consumption habits. We included these items in the questionnaires.

### Discussion groups

Discussion groups with farmers and mothers of the communities took place in July and August 2014. The goal of these discussion groups was to develop an understanding of the communities' perspective to guide interpretation of quantitative data. In addition, group discussion is key to engage communities in meaningful reflections to identify actionable factors to promote change.[22] The CHW recruited community members for these groups. We aimed to run two groups in each community (except in Chilcapamba, as this community was surveyed in 2013): one with mothers and one with farmers, with about 10 participants each. Discussion was in Kichwa and Spanish based on the preference of the participants. A CHW moderated each group and posed the discussion question.

Discussion was initiated by asking a sole question in each group. The CHW asked mothers why they feel nutrition is a problem in their community and farmers why they think agriculture changed in their community in recent years. Discussion was concluded by having the CHW list the factors raised during discussion and asking the group to rate their importance on a scale of 1–5; 1 being least important and 5 being most important.

Two authors (JW and ES) with the assistance of CHW took notes on the discussion of factors relating to nutrition and agriculture. We chose not to audio record these groups under advice from the CHW who felt it would impact the quality of the discussion.

### Questionnaire

The authors (SM in Chilcapamba, JW and ES in all other communities) accompanied by a CHW administered the questionnaire to each household with children between 6 months and 12 years of age. We offered the questionnaire to all qualifying households. This questionnaire included 62 items and is available as an online supplementary file.

The CHW asked to interview the person who regularly prepares household meals on the assumption that they are most knowledgeable about nutritional habits. This was most commonly the mother of the youngest generation living in the household, but very occasionally the grandmother or eldest sister. Interviewers obtained verbal consent prior to starting the questionnaire, and CHW translated from Spanish to Kichwa when necessary. We administered the questionnaire during the dry season (July and August) using the same technique in all communities. The questionnaire was administered in Chilcapamba in 2013 and in the three other communities in 2014. Two questions were added to the questionnaire in 2014: household crowding and household income.

The questionnaire contained four sections: demographic information, agricultural information, food frequency and food security. The demographic section contained 14 questions relating to participant age, marital status, level of income, level of education and household characteristics. Income was converted from a continuous variable into a binomial using categories below and above minimum wage (US$340/month). The agriculture section contained nine questions regarding the type of crops grown and animals raised, whether they were used for sale or consumption, the use of fertiliser or pesticides, and the use of traditional agricultural practices. The food frequency section asked participants to identify whether 21 types of foods had been consumed in their household in the last 24 hours. We developed the list of foods from dietary habits of the population with input from a nutritionist familiar with Latin American diets, and aimed to recognise both traditional and Western food items. We did not establish the amount of foods consumed. We did not inquire about hunting practices as this is not part of the practices of these communities.

The Latin American Household Food Security Measurement Scale (ELCSA) is validated for use in Latin America to determine the level of food security based on the United States Department of Agriculture household food insecurity access scale.[23] It consists of 15 questions regarding frequency of events in the last month: feeling worried about having enough food, eating less than needed so children could have enough and not having enough food, among others. The ELCSA places households into categories of absent, light, moderate and severe food insecurity, but we used a binomial of food secure (including the absent and light categories) and food insecure (including moderate and severe categories).

We wrote all sections of the questionnaire first in English and later translated them to Spanish, with review by CHW to ensure agreement with local language use. We completed hard copies of questionnaires at the time of each household interview and later entered data into Excel spreadsheets.

### Biometric assessments of children

The authors (SM in Chilcapamba and ES and JW in all other communities), with assistance of trained CHW, measured and weighed children between the ages of 6 months and 12 years living in the surveyed households at three centralised measurement locations (schoolhouses within each community). Parents gave their verbal consent at the time of questionnaire administration, and they brought their children to the predetermined site for measurement. Children were measured within 2 weeks of their household having completed the questionnaire. We measured the height (in centimetres) and weight (in kilograms) of each child and recorded values using standardised techniques,[24] height against a wall with a measuring tape secured in place and a platform placed over the head of the child (MIES Wooden Measuring Rod 2011). We measured weight with a calibrated portable scale (Measuretek Portable Digital Scale SN0079099).

We plotted each child's height and age (HFA), as well as their body mass index (BMI, index of weight for height) and age to assess if they were stunted or overweight, respectively. We used WHO growth curves. Stunting was defined as HFA two or more SD below average, and overweight was defined as BMI two or more SD above average.[25]

### Quantitative analysis

We performed a quantitative analysis using CIETmap (V.2.5 beta 9.5),[26] an epidemiological analysis program that uses the open-source R programming language. We calculated the proportion for each variable and the corresponding percentage. The units of analysis were children. The analysis related three main outcomes (ie, stunting, overweight and food security) with the items on the questionnaires. Analysis excluded missing data.

Bivariate analysis tested unadjusted associations between outcomes and household or community factors and determined the OR and Cornfield 95% CI.[27] We adjusted for clustering (by community) using the method of Lamothe (ORa and 95% CIa) to avoid overestimation of statistical confidence.[28] The basic principle is that a cluster sample has a smaller variance than a random sample of the same size, due to the common sense principle that people living together tend to be more similar than those living apart. In statistical terms, this would be expressed in more narrow CIs.

We used the Mantel-Haenszel procedure to determine the independence of significant associations found during bivariate analysis.[29] This multivariate analysis saturated model included all significant associations from the bivariate analysis for each outcome; we excluded variables stepwise excluding the weakest associations first until only the associations significant at the 5% level remained.

### Patient and public involvement

The research topic of childhood nutrition and growth was determined by the CHW, after discussion with participant community members and leaders. The researchers then developed the specific research questions and outcome measures with knowledge of the communities from previous work through the TEACH project. The CHW were involved in the study design by reviewing questionnaires to ensure appropriateness, and they were critical in recruitment and data collection. Following preliminary analysis, the researchers prepared a fact sheet that the CHW disseminated and discussed with each community.

## RESULTS

### Qualitative findings

We held five discussion groups with 6–10 participants in each: three groups composed of mothers (in Arrayanes, Iltaqui and Morales Chupa), and two groups of farmers (in Morales Chupa and Iltaqui).

We found convergence in the discussions with mothers and farmers about nutrition and agriculture, respectively. For example, farmers said agricultural practices had changed because they grow fewer traditional grains; mothers said eating less of their traditional grains could be a cause of childhood malnutrition. All three communities identified irrigation, loss of agricultural traditions and eating less quinoa as important factors. Other factors mentioned include: using cooking oil, consuming rice, use of chemicals in agriculture, level of income, parasite infections and land area available for farming (table 1).

### Quantitative information

A total of 139 households across four communities answered the questionnaire and consented to the measurement of their children. Three households (two in Arrayanes and one in Morales Chupa) did not participate because interviewers were unable to contact them or they refused. The respondent most commonly had an elementary school level education and cared for a household of seven family members on average. Most households earn income less than or equal to the minimum wage of the region (US$340/month). Table 2 summarises the frequencies of the factors under study.

We obtained anthropometric measurements on 298 children. A small, unknown number of children living in households that completed the questionnaire were not present to be measured. Based on HFA, we found that approximately half of the children in each community are stunted (144/296 or 48.6%), less than half of the children in each community are overweight (129/298 or 43.3%) and a small proportion of children are both stunted and overweight (46/298 or 15.4%). We found no relationship between stunting and overweight (ORa 1.41, 95% CIa 0.87 to 2.32). The majority of children in all four communities live in a food insecure household and this ranged from 85.2% (75/88 in Chilcapamba) to 48.8% (21/43 in Arrayanes).

Most children live in households that consume a daily diet comprised of rice (204/298 or 68.5%), corn (239/298 or 80.2%), potatoes (249/298 or 83.6%), fruits (214/298 or 71.8%) and vegetables (268/298 or 89.9%). Just under half of the respondents (143/288 or 49.6%) report eating meat in the past 24 hours. We found less frequent consumption of quinoa (41/298 or 13.8%), fish (31/298 or 10.4%), eggs (98/298 or 32.9%) and milk (119/298 or 39.9%).

Most children live in a household that owned animals (251/298 or 84.2%), and approximately half live in a household that sold their livestock for profit (142/273 or 52%). A minority of children live in households that sold their crops for profit (68/289 or 23.5%). Approximately half of children live in households that followed traditional agricultural practices (93/210 or 44.3%) and the majority live in households that did not report using chemicals in their agricultural practices (185/193 or 95.9%).

Bivariate analysis identified significant associations of risk factors and the three tested outcomes (table 3). Further analysis identified significant associations that remained independent after multivariate analysis (table 4). A child living in a household that sold livestock, have an illiterate primary caretaker or does not have access to irrigation is more likely to be stunted. Male children and those who live in a household that sells livestock are more likely to be overweight. Children who live in a household that earns less than minimum wage are more likely to be food insecure, while children who live in a household that consumed quinoa in the past 24 hours are more likely to be food secure (table 4).

## DISCUSSION

There was an association between socioeconomic factors and children's growth status and household food insecurity among indigenous Andean Kichwa in Ecuador. Caretaker illiteracy and household income below minimum wage correlate with childhood stunting and food insecurity, respectively. Additionally, the sale of livestock was significantly associated with childhood stunting and overweight. Lastly, access to irrigation was found to correlate with childhood stunting.

Stunting and overweight affected almost half of children. The prevalence of stunting in the four communities investigated is similar to other indigenous groups in Ecuador.[2 30] Similar to the body size changes noted in Amazonian Ecuador,[17] the increasing prevalence of overweight children in Indigenous Andean Ecuador suggests that these communities are also in a transition process.

Access to irrigation was associated with less stunting in children. Research done in Latin America[31 32] and rural Pakistan shows that irrigation can be protective against food insecurity.[33] Given the mountainous terrain and the presence of a dry and rainy season, irrigation is especially important to the communities involved in this study. It ensures a consistent source of water for their crops and

Table 1 Risk factors for poor childhood nutrition identified by mothers and farmers

| Factors identified by discussion groups | Concerns expressed by community members | Importance rating * | Relevant quotations |
|---|---|---|---|
| **Both mothers and farmers** | | | |
| Loss of traditional agriculture techniques | ► Loss of ancestral grains due to insects and crop failure<br>► The use of chemicals (fertiliser/ pesticides)<br>► Loss of the manure from traditional animals<br>► Not respecting the phases of the moon when cultivating | Morales Chupa<br>Mothers: 4<br>Farmers: 5<br>Arrayanes<br>Mothers: 4<br>Iltaqui<br>Mothers: 4<br>Farmers: 5 | ► *We are losing our love of the Earth.* |
| Eating fewer traditional foods | ► Increased use of cooking oil and rice<br>► Decreased consumption of quinoa: takes longer to prepare<br>► Availability of unhealthy snacks at school | Morales Chupa<br>Mothers: 5<br>Arrayanes<br>Mothers: 3<br>Iltaqui<br>Mothers: 2<br>Farmers: 3 | ► *Today our children eat rice, spaghetti, and chicken.*<br>► *We are very lazy because the grains take a long time to cook and we don't have time.* |
| Level of income | ► Not enough money to buy foods that they are unable to grow themselves | Morales Chupa<br>Farmers: no score<br>Arrayanes<br>Mothers: 1<br>Iltaqui<br>Mothers: 5<br>Farmers: no score | ► *We don't have a lot of grains because the crop harvests are decreased, and we cannot buy them.* |
| **Mothers only (regarding nutrition)** | | | |
| Parasitic infection | ► Children eating in unhygienic conditions and drinking contaminated water may result in infection | Morales Chupa<br>Mothers: 1 | ► *It is possible that parasites are preventing our children from absorbing the nutrients from their diet.* |
| **Farmers only (regarding agriculture)** | | | |
| Access to irrigation | ► Changing climate and rain patterns force farmers to depend on irrigation<br>► New crops require more water to grow | Morales Chupa<br>Farmers: 4 | ► *We cannot grow food when it doesn't rain; if the climate was as it was before this would not be a problem.*<br>► *The absence of irrigation has created a challenge for the cultivation of some crops, especially in this dry season.* |
| Land area | ► Inherited land is divided among all children decreasing the area used to sustain a family<br>► Not enough room to expand<br>► Decreasing soil fertility and land overuse | Illtaqui<br>Farmers: 2 | ► *Land areas are divided each generation among all the children, so each one gets a smaller piece.* |

*From 1 least to 5 most important.

thus a reliable source of nutrition for families. Discussion group participants explained that this is especially true in recent years where rain patterns have become unpredictable. La Frenierre *et al* has documented rain pattern changes within the region,[34] and other reports have noted the importance of irrigation in the absence of consistent rainfall.[35]

Other studies have used quantity of agricultural products sold as a proxy for market integration.[36] In our study, selling animals was associated with both overweight and stunting which may indicate an incomplete transition from subsistence farming to market integration, where households have a diversified income stream as they move from agriculture towards wage labour or cash cropping.[32] It may also indicate that there is a wide range of reasons that households sell animals; for example, a poorer household might sell an animal in a desperate situation, whereas a household of higher socioeconomic status would be more likely to plan to sell an animal for profit.

Male children were more likely to be overweight than female children, a trend that was not documented in school children in an Ecuadorian city,[37] and appears to be the opposite of the trend documented for adults in

**Table 2** Frequencies of risk factors, stunting, overweight and food insecurity per community

| | Chilcapamba | Morales Chupa | Iltaqui | Arrayanes | Total | Missing data |
|---|---|---|---|---|---|---|
| Factors specific to the children | | | | | | |
| Children per community | 88/298 (29.5%) | 107/298 (36%) | 60/298 (20.1%) | 43/298 (14.4%) | 298 | 0 |
| Male child | 38/88 (43.2%) | 55/107 (51.4%) | 36/60 (60%) | 22/43 (51.2%) | 151/298 (50.7%) | 0/298 (0%) |
| Food insecure | 75/88 (85.2%) | 69/107 (64.5%) | 37/60 (61.7%) | 21/43 (48.8%) | 202/298 (67.8%) | 0/298 (0%) |
| Agricultural factors of household | | | | | | |
| Household owned animals | 69/88 (78.4%) | 90/107 (84.1%) | 58/60 (96.7%) | 34/43 (79.1%) | 251/298 (84.2%) | 0/298 (0%) |
| Household sold crops | 20/88 (22.7%) | 10/99 (10.1%) | 18/60 (30%) | 20/42 (47.6%) | 68/289 (23.5%) | 11/298 (3.7%) |
| Household used chemicals | Data not collected | 3/91 (3.3%) | 3/60 (5%) | 2/43 (4.7%) | 8/193 (4.1%) | 104/298 (34.9%) |
| Followed traditional agricultural ways | Data not collected | 42/107 (39.3%) | 31/60 (51.7%) | 20/42 (46.5%) | 93/210 (44.3%) | 88/298 (29.5%) |
| Household had access to irrigation | 44/88 (50%) | 59/99 (59.6%) | 0/60 (0%) | 0/43 (0%) | 103/290 (35.5%) | 8/298 (2.7%) |
| Household sold livestock | 42/88 (47.7%) | 32/90 (35.6%) | 48/58 (82.8%) | 20/37 (54.1%) | 142/273 (52%) | 25/298 (8.3%) |
| Food frequencies in the past 24 hours | | | | | | |
| Consumed oil | 68/88 (77.3%) | 96/107 (89.7) | 52/60 (86.7%) | 31/43 (72%) | 247/298 (82.9%) | 0/298 (0%) |
| Consumed rice | 61/88 (69.3%) | 82/107 (76.6%) | 37/60 (61.7%) | 24/43 (55.8%) | 204/298 (68.5%) | 0/298 (0%) |
| Consumed sugar | 69/88 (78.4%) | 37/107 (34.6%) | 32/60 (53.3%) | 6/43 (14%) | 144/298 (48.3%) | 0/298 (0%) |
| Consumed meat | 47/88 (53.4%) | 80/107 (74.8%) | 22/59 (37.3%) | 3/43 (7%) | 152/297 (51.2%) | 1/298 (0.3%) |
| Consumed fruits | 56/88 (63.6%) | 80/107 (74.7%) | 45/60 (75.0%) | 33/43 (76.1%) | 214/298 (71.8%) | 0/298 (0%) |
| Consumed eggs | 29/88 (33%) | 40/107 (37.4%) | 20 (33.3%) | 9/43 (20.9%) | 98/298 (32.9%) | 0/298 (0%) |
| Consumed juice | 29/88 (33%) | 53/107 (49.5%) | 33/60 (55%) | 28/43 (65.1%) | 143/298 (48%) | 0/298 (0%) |
| Consumed milk | 43/88 (48.9%) | 56/107 (52.3%) | 13/60 (21.7%) | 7/43 (16.3%) | 119/298 (39.9%) | 0/298 (0%) |
| Consumed vegetables | 83/88 (94.3%) | 96/107 (89.7%) | 54/60 (90.0%) | 35/43 (81.4%) | 268/298 (89.9%) | 0/298 (0%) |
| Consumed corn | 65/88 (73.9%) | 86/107 (80.4%) | 52/60 (86.7%) | 36/43 (83.7%) | 239/298 (80.2%) | 0/298 (0%) |
| Consumed potatoes | 76/88 (86.4%) | 91/107 (85%) | 45/60 (75%) | 37/43 (86%) | 249/298 (83.6%) | 0/298 (0%) |
| Consumed fish | 8/88 (9.1%) | 19/107 (17.8%) | 2/60 (3.3%) | 2/41 (4.7%) | 31/298 (10.4%) | 0/298 (0%) |
| Consumed quinoa | 11/88 (12.5%) | 19/107 (17.8%) | 7/60 (11.7%) | 4/43 (9.3%) | 41/298 (13.8%) | 0/298 (0%) |
| Consumed soda | 33/88 (37.5%) | 25/107 (23.4%) | 10/60 (16.7%) | 8/43 (18.6%) | 76/298 (25.5%) | 0/298 (0%) |
| Household factors | | | | | | |
| Crowded household (>2 people/room) | Data not collected | 95/107 (88.8%) | 49/60 (81.7%) | 39/43 (90.7%) | 183/210 (61.4%) | 88/298 (41%) |
| Household earned below minimum wage | Data not collected | 46/91 (50.5%) | 37/56 (66.1%) | 25/42 (59.5%) | 108/189 (57.1%) | 109/298 (36.6%) |
| Primary caretaker was illiterate | 15/88 (17%) | 47/107 (43.9%) | 32/60 (53.3%) | 21/43 (48.8%) | 115/298 (38.6%) | 0/298 (0%) |
| Outcomes | | | | | | |
| Food insecure | 75/88 (85.2%) | 69/107 (64.5%) | 37/60 (61.7%) | 21/43 (48.8%) | 202/298 (67.8%) | 0/298 (0%) |
| Stunting | 41/86 (46.6%) | 45/107 (42%) | 39/60 (65%) | 19/43 (44.2%) | 144/296 (48.6%) | 0/298 (0%) |
| Overweight | 28/88 (31.8%) | 51/107 (47.7%) | 35/60 (58.3%) | 15/43 (34.9%) | 129/298 (43.3%) | 0/298 (0%) |

**Table 3** Risk factors associated with stunting, overweight and food insecurity in the four communities

| Risk factor<br>First line: exposure<br>Second line: non-exposure | Had outcome | OR (95% CIa) | Had outcome | OR (95% CIa) | Had outcome | OR (95% CIa) |
|---|---|---|---|---|---|---|
| | Stunting | | Overweight | | Food insecurity | |
| Factors specific to the children | | | | | | |
| Male child<br>Female child | 75/151<br>69/145 | 1.09 (0.63 to 1.89) | 76/151<br>53/147 | 1.80 (1.11 to 2.98)* | 103/151<br>99/147 | 1.04 (0.85 to 1.28) |
| Food insecure<br>Food secure | 102/200<br>42/96 | 1.34 (0.80 to 2.28) | 92/202<br>37/96 | 1.33 (0.80 to 2.28) | – | – |
| Agricultural factors of household | | | | | | |
| Household owned animals<br>Household did not own animals | 119/250<br>25/46 | 0.76 (0.30 to 1.93) | 110/251<br>19/47 | 1.15 (0.26 to 5.10) | 171/251<br>31/47 | 1.10 (0.44 to 2.80) |
| Household sold crops<br>Household did not sell | 36/68<br>103/219 | 1.27 (0.71 to 2.3) | 36/68<br>88/133 | 1.70 (0.95 to 3.10) | 45/68<br>152/221 | 0.89 (0.49 to 1.73) |
| Household used chemicals<br>Household did not use chemicals | 5/8<br>87/185 | 1.8 (0.32 to 74.72) | 6/8<br>86/185 | 3.45 (0.70 to 12.5) | 4/8<br>113/185 | 0.64 (0.06 to 6.26) |
| Followed traditional agricultural ways<br>Did not use traditional agriculture | 46/93<br>46/100 | 1.15 (0.62 to 2.13) | 45/93<br>47/100 | 1.06 (0.57 to 1.95) | 60/93<br>57/100 | 1.37 (0.74 to 2.60) |
| Household had access to irrigation<br>Household did not have access to irrigation | 35/102<br>103/186 | 0.42 (0.24 to 0.71)* | 49/103<br>76/187 | 1.33 (0.79 to 2.23) | 76/197<br>27/93 | 1.54 (0.89 to 2.83) |
| Household sold livestock<br>Household did not sell | 77/141<br>52/103 | 1.80 (1.09 to 3.06)* | 69/142<br>45/131 | 1.81 (1.08 to 3.08)* | 99/142<br>89/131 | 1.09 (0.63 to 1.89) |
| Food frequencies in the past 24 hours | | | | | | |
| Consumed oil<br>Did not consume oil | 122/246<br>22/50 | 1.25 (0.65 to 2.51) | 108/247<br>21/51 | 1.11 (0.58 to 2.25) | 170/247<br>32/51 | 131 (0.63 to 2.53) |
| Consumed rice<br>Did not consume rice | 94/202<br>50/94 | 0.77 (0.47 to 1.25) | 83/204<br>46/94 | 0.72 (0.51 to 1.01) | 135/204<br>67/94 | 0.79 (0.47 to 1.31) |
| Consumed sugar<br>Did not consume sugar | 65/142<br>79/154 | 0.80 (0.61 to 1.06) | 56/144<br>73/154 | 0.71 (0.41 to 1.21) | 105/144<br>97/154 | 1.58 (0.79 to 3.17) |
| Consumed meat<br>Did not consume meat | 66/142<br>75/144 | 0.80 (0.59 to 1.09) | 64/143<br>60/145 | 1.15 (0.86 to 1.52) | 106/143<br>93/145 | 1.60 (0.66 to 3.91 |
| Consumed fruits<br>Did not consume eat fruits | 61/131<br>46/84 | 0.72 (0.52 to 1.00) | 45/133<br>38/84 | 0.62 (0.42 to 0.90)* | 94/133<br>62/84 | 0.86 (0.31 to 2.38) |
| Consumed eggs<br>Did not consume eggs | 40/96<br>104/200 | 0.66 (0.53 to 0.82)* | 49/98<br>80/200 | 1.50 (0.90 to 2.49) | 58/98<br>144/200 | 0.56 (0.41 to 0.77)* |
| Consumed juice<br>Did not consume juice | 64/141<br>80/155 | 0.78 (0.52 to 1.17) | 67/143<br>62/155 | 1.32 (0.70 to 2.49) | 84/143<br>118/155 | 0.45 (0.17 to 1.14) |
| Consumed milk<br>Did not consume milk | 52/119<br>92/177 | 0.72 (0.54 to 0.96)* | 47/119<br>82/179 | 0.77 (0.46 to 1.29) | 83/119<br>119/179 | 1.16 (0.30 to 4.48) |

Continued

**Table 3** Continued

| Risk factor<br>First line: exposure<br>Second line: non-exposure | Had outcome | OR (95% CIa) | Had outcome | OR (95% CIa) | Had outcome | OR (95% CIa) |
|---|---|---|---|---|---|---|
| | Stunting | | Overweight | | Food insecurity | |
| Consumed vegetables<br>Did not consume vegetables | 126/266<br>18/30 | 0.60 (0.22 to 1.64) | 118/268<br>11/30 | 1.36 (0.40 to 4.66) | 182/268<br>20/30 | 1.06 (0.20 to 5.50) |
| Consumed corn<br>Did not consume corn | 120/239<br>24/57 | 1.39 (0.60 to 3.18) | 106/239<br>23/59 | 1.25 (0.81 to 1.92) | 156/239<br>46/59 | 0.53 (0.21 to 1.33) |
| Consumed potatoes<br>Did not consume potatoes | 115/248<br>29/48 | 0.57 (0.24 to 1.31) | 108/249<br>21/49 | 1.02 (0.28 to 3.72) | 176/249<br>26/49 | 2.13 (1.74 to 2.61)* |
| Consumed fish<br>Did not consume fish | 11/31<br>133/265 | 0.55 (0.25 to 1.47) | 13/31<br>116/267 | 0.94 (0.62 to 1.43) | 12/31<br>190/267 | 0.26 (0.22 to 0.30)* |
| Consumed quinoa<br>Did not consume quinoa | 19/41<br>125/255 | 0.9 (0.42 to 1.85) | 21/41<br>108/257 | 1.45 (0.70 to 3.05) | 14/41<br>188/69 | 0.19 (0.08 to 0.39)* |
| Consumed soda<br>Did not consume soda | 34/76<br>110/220 | 0.81 (0.49 to 1.35) | 30/76<br>99/222 | 0.81 (0.42 to 1.57) | 52/76<br>150/222 | 1.04 (0.48 to 2.24) |
| Household factors | | | | | | |
| Crowded household<br>Not a crowded household | 95/183<br>49/113 | 1.41 (0.86 to 2.35) | 88/183<br>41/115 | 1.67 (1.02 to 2.83) * | 114/183<br>88/115 | 0.51 (0.28 to 0.86)* |
| Household earned below minimum wage<br>Household earned more than minimum wage | 57/108<br>32/81 | 1.71 (0.92 to 3.28) | 49/108<br>40/81 | 0.85 (0.45 to 1.59) | 79/108<br>35/81 | 3.58 (1.90 to 7.22)* |
| Primary caretaker was illiterate<br>Primary caretaker was literate | 67/115<br>77/181 | 1.89 (1.15 to 3.16)* | 50/115<br>79/104 | 1.01 (0.61 to 1.67) | 74/115<br>128/183 | 0.78 (0.14 to 4.16) |

*Variables that were significant (p<0.05) and used for multivariate analysis.

Table 4 Final results of multivariate analysis of risk factors associated with stunting, overweight and food insecurity in the four communities

| Exposure | Adjusted OR | 95% CIa | Cluster adj $X^2$ MH |
|---|---|---|---|
| Stunting | | | |
| Household sold livestock | 1.77 | 1.06 to 2.95 | 4.74 |
| Primary caretaker was illiterate | 1.81 | 1.07 to 3.06 | 4.85 |
| Household had access to irrigation | 0.47 | 0.27 to 0.81 | 7.46 |
| Overweight | | | |
| Male child | 1.87 | 1.02 to 3.43 | 4.08 |
| Household sold livestock | 2.14 | 1.14 to 4.02 | 5.59 |
| Food insecurity | | | |
| Household earned below minimum wage | 2.90 | 1.56 to 5.41 | 11.25 |
| Consumed quinoa | 0.17 | 0.06 to 0.48 | 11.16 |

CIa, CIs using the method of Cornfield, adjusted for clustering with the method of Lamothe; cluster adj $\chi^2$ MH, cluster-adjusted $\chi^2$ Mantel-Haenszel.

Ecuador.[38] Preferential feeding of male children has been documented in other regions of the world but has not been clearly seen in the Andes.[39] This difference in nutritional status between males and females may be attributable to variations in activity levels and food consumption patterns among individuals within a household,[40] which may differ depending on the degree of market integration of a household.

In our study, caretaker literacy was inversely associated with stunting. Urke *et al* suggested that women who are better educated are more likely to take advantage of the few available resources in their rural setting and therefore more able to secure good nutrition for their children.[41] Furthermore, the quantitative analysis revealed that an income below minimum wage was significantly associated with food insecurity. Discussion groups also indicated that income was an important factor in food insecurity and nutrition. Low income is associated with food insecurity and poor health status in both developed and developing countries[42 43]; the difference lies in overweight, where in developed countries it is associated with poverty,[42] but in low-middle income countries it is associated with higher socioeconomic status.[44] However, programmes that address income independent of other variables (like education) are ineffective at improving childhood health status.[45 46] Larrea and Kawachi suggested that socioeconomic inequality is a predictor of poorer health outcomes independent of absolute income.[47] Conversely, poverty alleviation in addition to maternal education may work symbiotically to improve childhood health.[48] Evidence like this reveals the high potential for confounding between income, maternal education and childhood health.[49]

This study further demonstrated that households that reported consumption of quinoa were less likely to report food insecurity. Quinoa is an important part of traditional agriculture in Ecuadorian highlands and was used in this study as a proxy. All three communities voiced that the loss of traditional agricultural practices and decreased consumption of traditional food were main contributors to childhood malnutrition. Many mothers described difficulty enticing their children to eat traditional foods, because they preferred the processed snacks available at school. In Brazil, young people had less interest in consuming wild edible plants due to perceived negative cultural acceptance.[50] Other researchers have argued for the value of maintaining local food biodiversity as well as traditional agricultural knowledge.[35 51] One study found that higher income reaped from high-intensity, high-input farming of non-traditional crops was associated with worse nutritional outcomes for children in those households compared with moderate-intensity to low-intensity farming households that rely on locally available inputs.[52] Several factors, including perceived usefulness or convenience of alternatives, may drive the loss of traditional knowledge in cultural transition,[53] and this loss may have costs associated with poorer childhood health outcomes like growth potential, stunting and excessive immunostimulation.[54]

This study faced several limitations. Analysis was limited by low statistical power despite the inclusion of almost all households in the participating communities. This is a common feature of studies involving remote indigenous communities. Food frequency questionnaires provide only a limited snapshot into food habits and can miss important differences in seasonal and daily nutritional intake. Food frequency questionnaires do not account for the quantity of a food group consumed and can therefore overestimate or underestimate the intake of certain foods. Although we tried to maintain the same methods between the two periods of data collection, two items were added to the questionnaire for the second summer of data collection (ie, household crowding and household income). We encountered some difficulty communicating with participants who spoke only Kichwa; we were able to rely on CHW for translation assistance, but some information may have been omitted.

## CONCLUSIONS

The indigenous communities we partnered with are in a tumultuous period of cultural, nutritional and epidemiological transitions, and many complex, internal and external factors affect these processes, including market integration, weather patterns and community mindset. Our study suggests that some deleterious health effects on children could be minimised with effective community interventions. This study is significant because it provides the community with information to guide future health interventions, and data to support the path towards those interventions (eg, funding, regional governmental support, community engagement). Deliberation among community leaders and members over the information this study provides will be critical to determine how best to address these problems of childhood stunting, overweight and food insecurity. Important factors for discussion include ways to maintain and grow traditional knowledge and resources, and ways to adopt and improve on Western resources like irrigation, primary health education, gender equality and income.

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**Patient consent** Obtained.

**Ethics approval** The Internal Review Board of McGill University approved this study and its use of human subjects (IRB Study Number A04-B11-12B). We attest that we have obtained appropriate permissions and paid any required fees for use of copyright protected materials.

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**Data sharing statement** The datasets generated during or analysed during the current study will be available upon request from the corresponding author. Before the information can be shared, the requester will need to present a plan for data analysis. Also, the requester will need to complete the procedure for ethical approval of the secondary analysis following the procedures defined by McGill University's Institutional Review Board and the agreements with communities to ensure the protection of the participants.



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