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RESEARCH ARTICLE

A prospective cohort study of economic and nutritional changes during the COVID-19 pandemic in urban Callao, Lima, Peru [version 1; peer review: awaiting peer review]

Nutrition and COVID-19 risk factors in Peru

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Abstract

Background: Peru followed strict quarantine measures to control COVID-19 but reported excess mortality rates during the pandemic that were the highest globally. High obesity prevalence in Peru may have contributed to COVID-19 mortality, although economic hardship during the pandemic could have reduced obesity. To investigate these potential associations, we updated surveys of economic status, nutritional status, and risk factors for severe COVID-19 in residents of Callao, in the Lima metropolitan area of Peru.

Methods: We attempted in December 2021 to invite members of households selected randomly from a map that had provided data in previous surveys 2016-2018 and 2019-2020 to participate in another survey. Households were contacted by telephone and, if uncontactable, were visited. Demographic, economic, and health-related data were collected using the Kobo toolbox platform.

Results. We interviewed 83% (305/369) of censused household members for 65% (90/138) of previously participating households. Dissaving activities were reported by all households during the pandemic, more than 2016-2018 (51%, 95% confidence interval, CI=41-62%) and 2019-2020 (44%, 95%CI=33-53%, both p<0.0001). Moreover, 90% (81/90, 95%CI=82-95%) of households reported inability to afford

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sufficient food and hunger rates increased 1.4 times compared with 2016-2018 (95%CI=1.02, 2.0, p=0.04). Despite financial and food insecurity during the pandemic, the mean adult body mass index was maintained unchanged from the 2019-2020 survey at 27 kg/m^2 (standard deviation, SD=4.5 kg/m^2), having increased (p=0.0001) from 26 kg/m^2 (SD=4.1 kg/m^2) in 2016-2018. Overweight/obesity was the most common risk factor for severe COVID-19, and adults were 3.1 times (95%CI=2.3-4.2, p<0.0001) more likely to be overweight/obese than they were to have a co-morbid illness. There was considerable dietary diversity and only 23% of participants had taken micronutrient supplements and 11% probiotics in the past year.

Conclusion: Obesity was the most prevalent risk factor for severe COVID-19 despite economic pressure, food insecurity, and hunger during the pandemic.

Keywords
COVID-19, food insecurity, financial insecurity, co-morbidities, obesity, nutrition, diet, Peru

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Introduction

Peru reported its first case of COVID-19 on 6th March 2020, and by the 16th March 2020 it started a national military enforced 'lock down' of approximately three months duration that allowed only essential activities, followed by curfews that lasted into 2021, with ongoing compulsory mask use and ongoing closure of many educational institutes for face-to-face interactions. Despite these prompt and stringent enforced interventions aiming to reduce SARS-CoV-2 viral transmission, more than 200,000 deaths (>0.6% of population) have been attributed directly to COVID-19 in Peru, which is the country with the highest all-cause excess mortality rate reported globally[1–3].

Severe COVID-19 illness and death disproportionately affect specific populations. A potent risk factor is increasing age, and mortality rates for those ≥60 years of age are 22 times higher than those <60 years old[4,5]. Yet, Peru's population is relatively youthful with only 6.8% of the population being >65 years old[6]. Many of the illnesses that are also considered risk factors for severe COVID-19 have poorly defined prevalence in Peru, especially in the urban poorer areas that have been worst affected by COVID-19. However, these comorbid illnesses are also generally associated with increasing age. Therefore, age and comorbid illnesses alone would not seem to be likely explanations for why Peru has been severely affected with a high mortality during the COVID-19 pandemic.

Peru had undergone a rapid economic expansion over the past decade, so much so that it is now considered an upper middle-income country. However, 75% of the Peruvian population are informally employed and prolonged restrictions on movement during the pandemic have led to employment falling by 20%, causing an estimated additional 4.5 million people to meet the definition of poverty[7,8]. Deprivation has been found to be an independent risk factor for severe COVID-19 disease, which is only sometimes attributable to comorbid illnesses[9]. Increasing financial insecurity has likely worsened overcrowding and may challenge ability to follow 'stay-at-home' orders, which may have worsened COVID-19 infection rates in poorer communities[10].

The World Bank reported that during the beginning of the pandemic there was an alarming increase in food insecurity in Latin American countries, stating that 40% or more of households had run out of food since the lockdown[11,12]. In their report, the main mechanism to cope with the economic pressures of the pandemic was reported to be a reduction of food consumption, thus potentially increasing malnutrition and undernutrition[11]. Population level data have demonstrated that undernutrition and iron deficiency in particular, are associated with high COVID-19 fatality rates[13]. This would be in keeping with data demonstrating the link between micronutrient deficiency and immune dysregulation, increasing risk of some other infectious diseases[14,15]. However, paradoxically, obesity is a potent risk factor for severe COVID-19, increasing a person's odds of adverse outcome 2.6 times[16]. Studies have shown that food insecurity can counter-intuitively increase obesity, potentially mediated by decreased dietary quality[17]. Consequently, although obesity has conventionally been associated with excess food intake, it may occur together with deficiency of protein and micronutrients[18].

Dietary supplementation has been shown to reduce disease severity in some viral upper respiratory tract infections[19,20]. Consequently, there has been speculation concerning the possible role of dietary supplementation to prevent or even treat severe COVID-19, although the available evidence is sparse and generally of poor quality[21]. During the pandemic there has been an increased global demand for dietary supplements as many of the general public, at their own cost and potentially in the face of food insecurity, have been taking supplements because they hope that this may mitigate their risk of severe COVID-19 illness.

The objectives of this study were to use a four-year prospective cohort study to characterise economic and nutritional changes after approximately two years of the COVID-19 pandemic in urban Callao, Peru, focusing on how changes in overweight/obesity, co-morbid illnesses, and other risk factors for severe COVID-19 may explain Peru's high mortality during the pandemic; with reference to evaluating dietary diversity and the use of dietary supplements.

Methods

Ethics statement

Data was collected as part of a larger ongoing cohort study and ethics approval was given by the following committees: the Peruvian Ministry of Health DIRESA Callao, Peru, reference 790-2014-DG; Asociacíon Benefica Prisma, Peru, reference CE0970.16; and Imperial College London, UK, reference 14IC2191. All participants provided written informed consent.

Study setting

This study was carried out in the Province of Callao, where approximately one million people reside. This province is contiguous with the capital of Peru, Lima, and is part of the Lima metropolitan area. Our research group has worked with 32 of the 45 communities constituting this province for over six years in community-based research regarding tuberculosis (TB) prevention and cure. These communities were selected for their high levels of poverty, population density, and high TB case notification rates. The participating communities are separated into two distinct areas: 15 in desert shantytowns and 17 urban communities[22].

Household selection method

Between August 2016 and September 2018, community control households were recruited randomly, as previously reported[22]. Using detailed maps of each community, residential 'blocks' were allocated numbers; then with random number tables residential 'blocks' were selected and then located; using another random number table a residential property within the block was selected. If the selected 'block' did not have a cardinal numbering system of properties, then the North-West corner of the selected 'block' was located and from there residential properties were counted in a clockwise direction, and

the corresponding household approached. If no adults (defined as a person ≥18 years old) were available to provide informed written consent, then another randomly selected household in the selected block was visited. Recruited households were revisited from January 2019 to March 2020 (before the first case of COVID-19 was identified in Peru) to evaluate any changes since the baseline data was collected. There were 138 households that provided data at these two pre-pandemic timepoints and these were invited to participate in the current survey.

The sample size was opportunistic, as described above.

Data collection
All questionnaires were written in Spanish and were piloted and refined by the research team working with the target population prior to use for research data collection.

Measurements in previous surveys
Household census, demographic, and vital status was recorded at each time point, along with household assets, economic markers, and the need to carry out any activity due to lack of sufficient funds to meet household needs, termed 'dissaving'. Each household member was then weighed, and their height measured at each time point as well as being asked questions regarding educational attainment. All data was collected face-to-face with paper-based questionnaires, that have been used in this research site for 15 years[22,23]. The items within these questionnaires that are presented here can be reviewed in the "questionnaire and data dictionary" files with corresponding English translations (see data availability section)[24,25].

Current pandemic survey method
In December 2021, using the contact details previously provided, members of the 138 households described above were called and asked to complete a short survey. Research staff were to make a maximum five attempts to contact the household via telephone. If households were unable to be reached via telephone, research staff then visited their home a maximum of three times to carry out the survey face-to-face or update the contact numbers on record and arrange a later time for interview. To demonstrate any sampling bias, the demographic characteristics of households that did not participate in this current 2021 survey were compared to the demographics of the households that did participate.

Measurements in the current pandemic survey
All data for this current 2021 survey was collected electronically using the KoBoToolbox platform (https://www.kobotoolbox.org/, Harvard University, Cambridge MA, USA). Data regarding household economy, dissaving, and individual weight was collected again (although this time weight was self-reported) to compare with data from previous timepoints. In response to the COVID-19 pandemic data characterising the following were collected: household food insecurity, hunger and each person's previous history of COVID-19, chronic diseases (diabetes, TB, HIV, cancer, kidney disease, asthma, COPD, bronchiectasis, or heart disease), dietary diversity, the use of dietary supplements, and belief of their role in the prevention of respiratory infections. These questionnaire items can be reviewed in the "questionnaire and data dictionary" files with corresponding English translations (see data availability section)[24,25].

Categories for nutritional status
Body mass index (BMI) was calculated for participants that were ≥20 years old. Categories for nutritional status was defined using the following BMI cut-offs: <18.5=underweight; 18.5-24.9 healthy weight; 25.0-24.9 overweight; and ≥30 obese. As only self-reported weight was asked in the current 2021 survey, to calculate BMI in those ≥20 years old at this time point the measured height in the previous survey was used. This was considered acceptable as height is relatively stable from 18 years onwards, and those who had recently become 20 years old would have been ≥18 years in the 2019–2020 survey, when we had last measured their height[26]. For participants <20 years old, weight-for-age Z scores for each time point were calculated instead of BMI. Weight-for-age Z score were calculated using the Stata 'zanthro' command and the CDC reference tables, as these tables were thought to be the most relevant and were the only ones that covered all ages <20 years old[27]. Categories for nutritional status using weight-for-age Z score for this entire age group are not commonly used, so they were defined with cut-offs that have been reported in the literature with the best predictive value with the gold standard BMI-for-age Z scores cut-offs: <-2 SD underweight; 75th-89th percentile overweight; and ≥90th percentile obese[28,29]. Categories for nutritional status data could be presented and analysed for all participants, whereas BMI data was only compared for participants who were aged ≥20 years in all three surveys, and weight-for-age Z score data were only compared for participants who were <20 years only in all three surveys.

Statistical analysis
All data are presented as either household or individual participant data accordingly, and are available as described in the data availability section[24,25]. Data were analysed with Stata version 16 (StataCorp, College Station, TX). Proportions are reported with their 95% confidence intervals (95%CI). Data comparing current 2021 data with data from previous surveys were analysed using paired methods such as a two-sided Wilcoxon signed rank test for nonparametric data, paired T-test for parametric data or McNemar test for binary data. All data that were collected only during the current 2021 survey, i.e., were not repeated measures, are described as cross-sectional results. As there was very little missing data from participants in the current 2021 survey, no imputation techniques were necessary.

Results
Household participation in 2021 survey
Figure 1 shows that out of 138 households who had provided data in the previous 2016–2018 and 2019–2020 surveys, 22% (30/138) were contactable via telephone. The reason households were uncontactable via telephone were because; 25% (35/138) had no telephone number recorded (three because they had

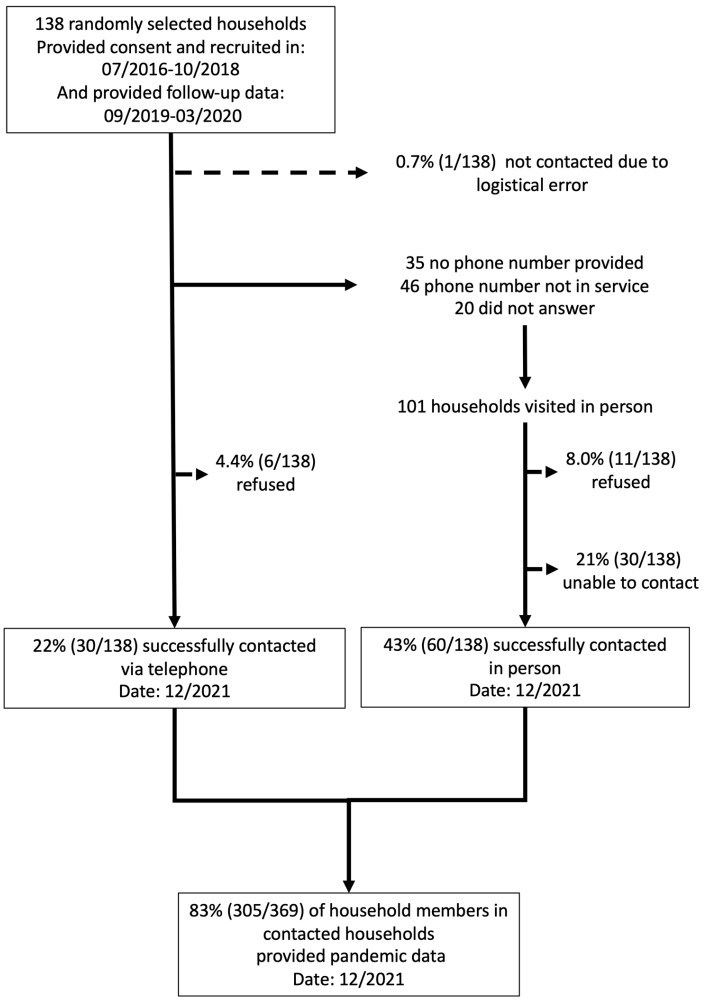

Figure 1. Study flow chart.

no access to a landline or mobile telephone); 33% (46/138) provided numbers that were no longer in service, and 15% (20/138) chose not to answer. As shown in Figure 1, after the round of telephone surveys, households that were uncontactable via telephone were visited and 60 more households were able to be interviewed. Thus, we were able to interview 65% (90/138) of households who participated in the previous 2016–2018 and 2019–2020 surveys. Compared to households who did participate in the 2021 survey, households who did not participate reported a 400 Peruvian Soles that is approximately $102 ($ indicates United States dollars) lower monthly income in 2019–2020 (p=0.01), although all other economic markers were similar (Table 1).

Household economy

The 2021 median monthly household income was 1,575 Peruvian Soles (approximately $400), that was similar to the 2019–2020 survey in cash terms (p=0.7, Table 1). Furthermore, 100% (90/90) of households reported that due to lack of funds in 2021 they had to carry out at least one of the dissaving activities shown in Figure 2. This was significantly more (p<0.0001) than in 2016–2018 at 51% (44/86, 95%CI=41%, 62%) and significantly more (p<0.0001) than 43% in 2019–2020 (38/88, 95%CI=33%, 53%). Most households reported that due to lack of funds in 2021 they had to: use their savings (83%, 75/90, 95%CI=74%, 90%); sell household objects (81%, 73/90, 95%CI=73%, 89%); and default on payments (64%, 58/90, 95%CI=54%, 74%, Figure 2). They also reported that 77% (69/90, 95%CI=67%, 86%) of households had a family member who had to leave studies due to lack of funds, but this finding may have been complicated by the national closure of all educational institutes during the pandemic.

Household food insecurity

Most households reported that during 2021, 86% (78/90, 95%CI= 78%, 93%) were fearful that their groceries would run out before acquiring enough money to buy more; and 90% (81, 95%CI=82%, 95%) reported that at times their groceries did not last to meet their needs and they had insufficient funds to buy more.

Table 1. Comparison of household characteristics. Part A. is a comparison for the 90 households that were interviewed in the current survey versus in previous surveys. None of these variables were significantly different between 2021 versus 2016–2018 or versus 2019–2020 (all p>0.1). Part B shows past data for the 48 households that did not participate in the current survey. All values that were significantly different (p<0.05) from the 90 household that did participate are shown in bold typeface.

	2016–2018	2019–2020	2021
A. In the 90 households who participated in the 2021 survey			
Educational attainment of head of household, % completed secondary (n)		71% (62)	
Number of total household members, median (IQR)	5 (3,7)	5 (3,7)	4 (3,6)
Number of household members ≤17 years old, median (IQR)	1 (0, 2)	1 (0, 2)	1 (0, 2)
Monthly household income, median PEN (IQR)*	-	1600 (1000, 2300)	1575 (930. 2500)
Total debt, median PEN (IQR)	0 (0,1000)	0 (0, 2000)	0 (0,2000)
Weekly food spending, median (IQR)	175 (140, 210)	210 (140, 280)	210 (150, 250)
B. In the 48 households that did not participate in the 2021 survey			
Educational attainment of head of household, % completed secondary (n)		60% (28)	
Number of household members, median (IQR)	4 (3,5)	4 (4,6)	-
Number of household members ≤17 years old, median (IQR)	1 (0, 2)	1 (0, 2)	-
Monthly household income, median PEN (IQR)*	-	**1200 (800, 1800)**	-
Total debt, median PEN (IQR)	0 (0, 250)	0 (0, 2500)	-
Weekly food spending, median (IQR)	183 (140, 210)	200 (140, 245)	-

Footnote. *=Income data was not collected in the first round of data collection in these household

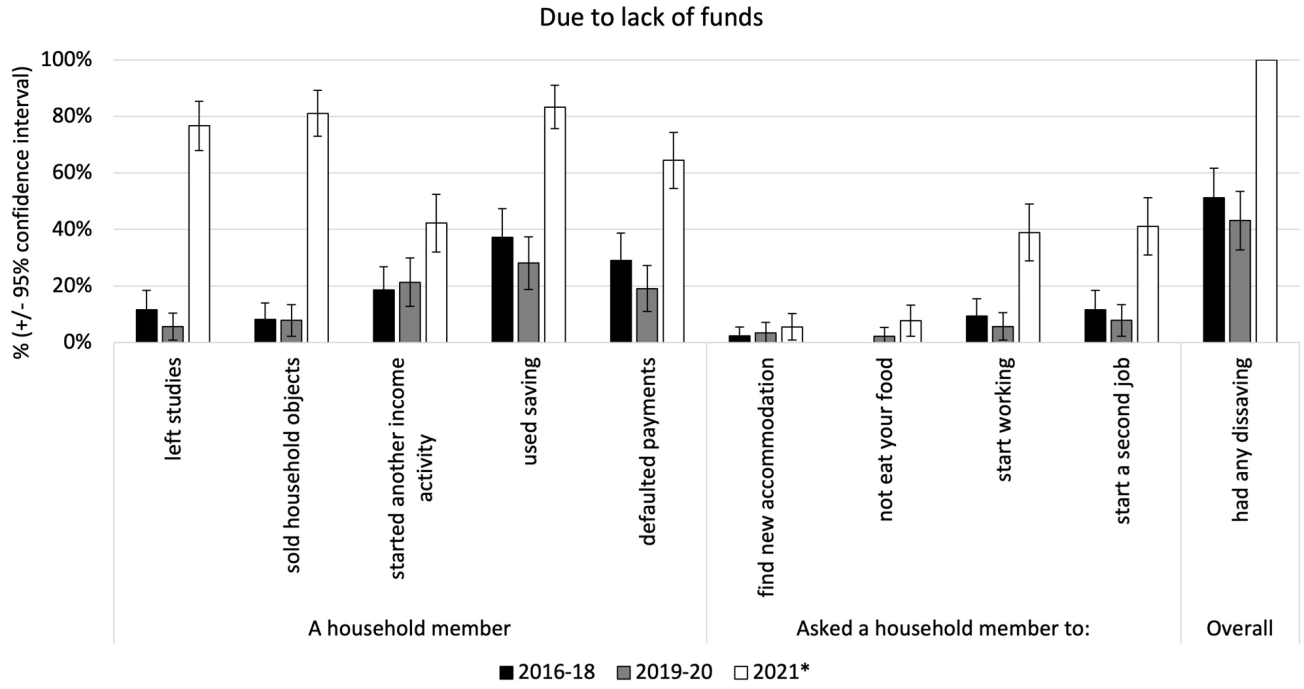

Figure 2. Bar graphs comparing the proportion of dissaving activities due to lack of funds reported in the participating 90 households in 2016–2018 (86/90), 2019–2020 (88/90) and the current pandemic survey in 2021 (90/90). Error bars show the 95% confidence intervals. Footnote. * In 2021, participants were asked about these activities since the start of the pandemic restrictions in Peru 16th March 2020), whereas in previous surveys they were asked about these activities over the past 2 months.

Participant characteristics

Within the households that participated in the 2021 survey, 369 people had been censused as household members in previous surveys, however 3.0% (11/369, 95%CI=1.5%, 5.2%) had died since the 2019–2020 survey and 14% (53/369, 95%CI=11%, 18%) of whom were alive but were unavailable to be interviewed. Therefore, data for the 2021 survey was collected from 305 household members, who we term 'participants'. Participants had a median age of 28 years (interquartile range, IQR=14, 48), of whom 60% (184/305) were female. Participants reported that 19% (57/305, 95% CI=14%, 24%) had COVID-19 previously, whilst 10% (31/305, 95%CI=7.0%, 14%) were currently diagnosed or experiencing illness due to COVID-19.

Participant hunger

In the 2016–2018 survey, 14% of participants (41/303, 95%CI=9.9%, 18%) experienced hunger for at least one day in the past month and this increased to 19% in 2021 (58/304, 95%CI=15%, 24%) which was a 1.4-times increased rate (95%CI=1.02, 2.0, p=0.04). (For this variable, comparable 2019–2020 data were unavailable for operational reasons).

Participant nutritional status

In 2016–2018, the mean BMI of the 59% (181/305) of participants who were ≥20 years old was 26 kg/m^2 (standard deviation, SD=4.1), in 2019–2020 this increased to mean BMI=27 kg/m^2 (SD=4.0, p=0.0001), and in 2021 this remained similar (mean BMI=27 kg/m^2, SD=4.5, p=0.3, Figure 3a). In the 35% (107/305) of participants who were aged <20 years in all three surveys, the weight-for-age Z scores did not differ significantly over the three time-points (all p>0.2), but had an increasing trend in 2021 (Figure 3b). Thus, as shown in Figure 3c, in 2016–2018, 44% of all participants were considered overweight/obese (134/303, 95%CI=39%, 50%), which increased significantly in 2019–2020 to 50% (148/294, 95%CI=45%, 56%, p=0.007) and increased in 2021 to 52% (159/304, 95%CI=47%, 58%), which was a significant increase (p=0.0003) compared to 2016–2018 and a non-significant trend (p=0.4) compared to 2019–2020.

Participant co-morbid illnesses

The three most common prevalent co-morbid illnesses were: diabetes mellitus (4.9%, 15/305, 95% CI=2.7%, 7.9%), renal disease (4.6%, 14/305, 95% CI=2.5%, 7.6%), and current TB (1.6%, 5/305, 95% CI=5.3%, 3.8%). Consequently, as shown in Figure 4, 14% of participants (42/305, 95% CI=10%, 18%) had an existing illness considered to be a co-morbidity associated with increased risk of severe COVID-19. However, the prevalence of any co-morbid illness was significantly less than the prevalence of being overweight or obese, especially in participants ≥20 years old in 2021 (64% (125/197, 95%CI=56%, 70%, p<0.0001, Figure 4), who were 3.3-times (95%CI= 2.4, 4.4) more likely to be overweight or obese than have a co-morbid illness.

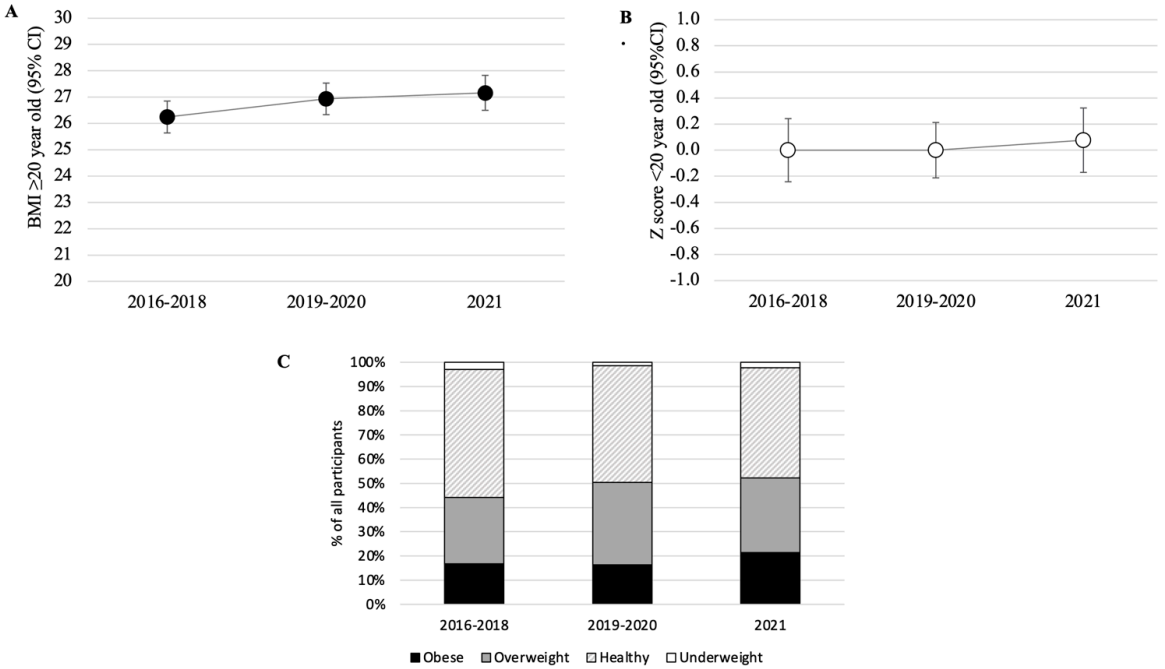

Figure 3. Nutritional status trends. (**A**) Body mass index (BMI) in participants ≥20 years old in all surveys (data for 175/181), (**B**) weight-for-age Z score in participants <20 years old in all surveys (data for 102/107); and (**C**) BMI categories in all 305 participants (data were available for 303 in 2016–2018, 294 in 2019–2020 and 304 in 2021). Note error bars show 95% confidence intervals (95% CI).

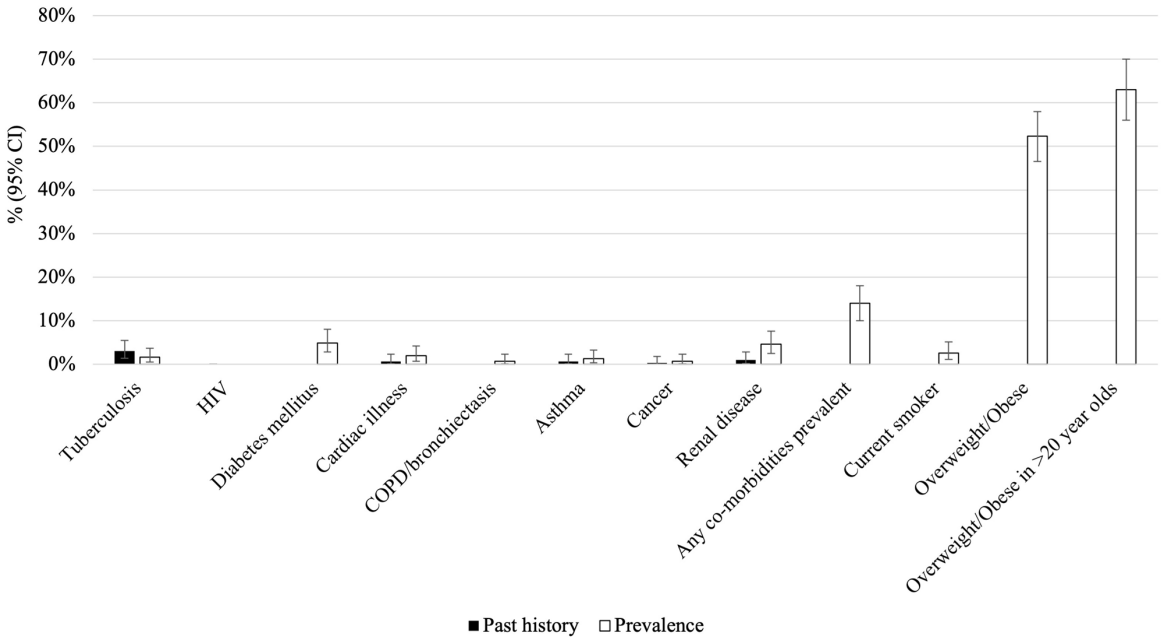

Figure 4. Self-reported past and current prevalence of known risk factors for severe COVID-19 in all 305 participants. Note HIV=human immunodeficiency virus; COPD=chronic obstructive pulmonary disease.

Participant dietary diversity

Data collection concerning dietary diversity was added to the questionnaire as a response to the COVID-19 pandemic, so this information was only available in 2021. Participants reported that the day before the 2021 survey they ate a median of three meals (IQR=3, 4). Figure 5 demonstrates that within these meals: 53% had consumed dairy (161/305, 95%=47%, 59%); 85% had consumed fresh fruit and vegetables (259/305, 95%=80%, 89%); 94% had consumed meat/fish (286/305, 95%=90%, 96%), 96% had consumed starch-based foods (292/305, 95%=93%, 98%) and 1.3% had consumed alcohol (4/305, 95%=0.36%, 3.3%).

Participant dietary supplementation

Data collection concerning dietary supplementation was added to the questionnaire because of concerns related to the COVID-19 pandemic. Consequently, this information was only available in 2021 and was then uncommon, with 23% of participants stating that they had taken micronutrient supplementation over the past year (69/305, 95%CI=18%, 28%): 57% because they hoped that this would improve their general health (39/69, 95%CI=44%, 68%), 36% because a health professional had advised them to (25/69, 95%CI=25%, 49%), and 5.8% because they hoped that this would prevent infectious diseases (4/69, 95%CI=1.6%, 14%). Only 11% of participants (32/305, 95%CI=7.3%, 15%), stated that they had taken probiotics over the past year: 97% because they hoped that this would improve their general health (31/32, 95%CI=84%, 99%) and 3.1% because a health professional had advised them to (1/32, 95%CI=0.0008%, 16%). When further questioned, 19% of all participants (57/305, 95%CI=15%, 24%) believed that dietary supplementation may help in the prevention of COVID-19 illness, whereas 15% (45/305, 95%CI=11%, 19%) believed dietary supplementation may help in the prevention of other respiratory infections such as TB. The supplements thought most likely to have a preventative role against COVID-19 were stated to be vitamin C (67%, 38/57) followed by zinc (11%, 6/57) and iron (7.0%, 4/57). The supplements thought most likely to have a preventative role against TB were vitamin C (38%, 17/45) followed by vitamin B complex (18%, 8/45) and iron (11%, 5/45).

Discussion

This four-year prospective cohort study characterised worsened income, dissaving, food insecurity, and hunger after approximately two years of the COVID-19 pandemic in urban Callao, Lima, Peru. Remarkably, these economic and nutritional challenges were associated with increasing overweight/obesity. Other risk factors for severe COVID-19 were infrequent. Consequently, overweight/obesity was by far the most prevalent risk factor for severe COVID-19, and this may partially explain Peru's high mortality during the pandemic. Micronutrient and probiotic dietary supplements were infrequently used, and few participants believed that they would protect them against COVID-19.

This study describes household economic impacts of the COVID-19 pandemic resulting in low income, dissaving, food insecurity, and more frequent hunger. These changes may not only increase the risk of severe COVID-19 but also have consequences on health that would be expected to continue beyond the pandemic. All surveyed households in this urban poor community in Callao, Lima, Peru reported that they had to undertake dissaving

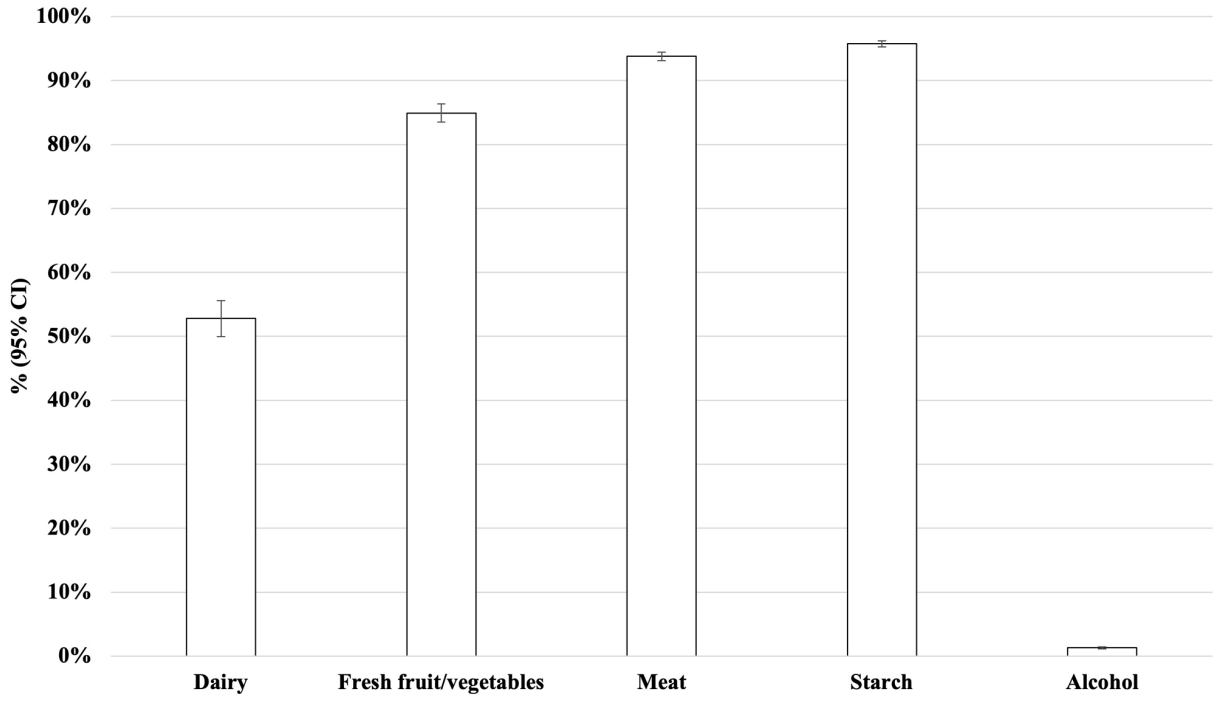

Figure 5. Dietary diversity. The percentage of all 305 participants who reported eating or drinking each type of nutrient the day before the 2021 survey. Note error bars indicate 95% confidence intervals (95% CI).

activities due to lack of funds during the COVID-19 pandemic. Furthermore, due to lack of funds, 90% of households were unable to make their groceries last sufficiently for their needs, with a 40% higher risk of experiencing hunger in 2021 then was previously reported by the same people. Paradoxically, the population BMI, which had been increasing in adults pre-pandemic, tended to increase further, particularly in under 20-year-olds. Thus, in 2021 most people were overweight or obese, and this was more than three-times more frequent than other known co-morbidities in adults that increase the risk of severe COVID-19 illness.

The pandemic was associated with stable household income in cash terms, however in real terms this would be a reduction in household income and households reported making profound dissaving adaptations. Hence, economic impact of the pandemic was measured in multiple ways, all of which indicated economic hardship. At this time, inflation was at its highest for 13 years due principally to higher food, transport and fuel prices[30,31]. Although these economic challenges could explain the food insecurity and hunger that we quantified, food insecurity was also increased by disruption to food supply chains due to pandemic restrictions and closure of and reluctance to visit fresh food markets because they had been identified as COVID-19 transmission hotspots[32]. Economic strain on families may have been further increased by the need to purchase items that were not required previously to prevent COVID-19; some due to mandatory measures by the government (such as face masks and face shields); others due to COVID-19 illness (such as medical care and procurement of treatment and equipment unavailable at clinics or for home-based care); and commercial products that were publicised to provide protection to COVID-19 (such as professional cleaning of houses and frequent stockpiling and purchasing of drugs with perceived therapeutic or protective effects such as ivermectin and corticosteroids).

In keeping with our findings, obesity in the population of Peru has also been steadily increasing between 1992–2017[33]. This has been attributed to concurrent changes seen in the diet that increased consumption of unhealthy, energy-rich foods[33]. A large cohort study in Peru also highlighted a complex pathway involving a so-called 'obesogenic environment' that includes a more sedentary lifestyle and unhealthy diet due to a wider exposure and convenience of fast food[34], the differential prices between healthy and unhealthy food that can be a prominent factor in food choice[35], as well as the rapid growth of the ultra-processed foods market in Latin America[36]. These factors were generally worsened by the pandemic because of restriction of movement, anxiety and fear of contagion, changes to the food supply chain, and economic strain.

The negative health impacts of obesity have been extensively reported and include cardiometabolic diseases, such as cardiovascular illnesses, stroke and diabetes, as well as potentially contributing to dementia and cancer[37,38]. The pandemic lock-down, quarantine, and closure of group childcare and all educational institutions in Peru for approximately 18 months

would all be expected to reduce physical activity and increase risk of becoming overweight or obese, as our results demonstrated. Childhood obesity has also been demonstrated to be associated with psychiatric, psychological, and psychosocial disorders in childhood as well as cardiometabolic diseases later in life[39]. Obesity is a strong risk factor for severe cases of COVID-19 and death[40]. The reason for this unknown but likely to be at least partially explained by metabolic dysfunction, chronic low grade inflammation, impaired immunity, compromised respiratory mechanics and association with other co-morbidities[40]. Ecological analysis showed a strong association between the prevalence of obesity and COVID-19 mortality rate even after adjusting for confounding factors[41]. Thus, overweight/obesity is likely to be an important, partial explanation for Peru having the highest reported excess mortality rates globally during the pandemic. Reducing overweight/obesity is notoriously difficult and it is unclear whether population level interventions such as promoting decreasing calory intake and increasing exercise as part of the COVID-19 pandemic public health messages might have reduced obesity and hence the risk of severe COVID-19.

Food insecurity not only impacts being under- or over-weight but can also impair micronutrient intake, which may adversely affect immune modulation. People who are obese also have high rates of micronutrient deficiency[42]. During the COVID-19 pandemic, global sales of dietary supplements increased, although there is little evidence to suggest that micronutrient supplementation has any beneficial effects related to COVID-19[43]. Interestingly in the current study, only a small proportion of participants reported that they had taken dietary supplements in the past year and/or believed that micronutrient supplementation could protect against COVID-19. Interestingly, the most frequent reason reported for taking dietary supplements was because of a recommendation by healthcare professionals, which would be expected to have worsened the economic strain on these households by adding to their costs.

The main limitation of the current study is a potential selection bias in the households that participated in the 2021 survey. Households that could not be contacted had reported a lower household income in previous surveys. Consequently, the data presented may under-represent poorer households, which could have been most adversely affected by the COVID-19 pandemic. Furthermore, our data concerning the prevalence of co-morbidities was self-reported and was likely an underestimate due to underdiagnosis in this setting. The main strength of this study is that the data in 2021 were compared within the same householdand/or person pre-pandemic to two previous time points, reducingpotential effects of recall bias. Thus, the results demonstratethe true impact of the pandemic on the background of an already evolving trajectory.

Conclusions

This study demonstrates that in a relatively poor urban Peruvian population during the COVID-19 pandemic, households adapted to reduced income, food insecurity, and hunger with diverse dissaving strategies. These changes were associated with high and increasing rates of overweight/obesity, which were by far the most prevalent risk factor for severe COVID-19. Therefore, the COVID-19 pandemic increases the need for research addressing worsening obesity, including for people living with financial hardship and hunger.

Data availability

Underlying data

Harvard Dataverse: Household survey results for "A prospective cohort study of economic and nutritional changes during the COVID-19 pandemic in urban Callao, Lima, Peru". https://doi.org/10.7910/DVN/4XVGU1[24].

This project contains the following underlying data:

- COVID_nutrition_economic_impact_household_survey_results_REPOSITORY_UPLOADED.xlsx (Anonymised responses for each household (n=138)).
- Questionnaire and data dictionary household_finalsurvey_REPOSITORY_UPLOADED.xlsx (Household questions and description of household data in anonymised data file in Spanish and English translated by first author).

Data are available under the terms of the Creative Commons Zero "No rights reserved" data waiver (CC0 1.0 Public domain dedication).

Harvard Dataverse: Individual survey results for "A prospective cohort study of economic and nutritional changes during the COVID-19 pandemic in urban Callao, Lima, Peru". https://doi.org/10.7910/DVN/WFS8S3[25].

This project contains the following underlying data:

- COVID_nutrition_economic_impact_n305_individual_survey_results_REPOSITORY_UPLOADED.xlsx (Anonymised responses for each participant (n=305)).
- Questionnaire and data dictionary individual_finalsurvey_REPOSITORY_UPLOADED.xlsx (Participant questions and description of individual participant data in anonymised response file in Spanish and English translated by first author).

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Reporting guidelines

Harvard Dataverse: STROBE checklist for 'A prospective cohort study of economic and nutritional changes during the COVID-19 pandemic in urban Callao, Lima, Peru'. https://doi.org/10.7910/DVN/012HFY[44].

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