Early agriculture's toll on human health

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It is difficult to envision a world without agriculture. However, as recently as 10 millennia ago, only in the Near East had people turned from hunting and gathering to agriculture as a means of supporting themselves. One such place was Çatalhöyük in modern-day Turkey, the subject of Larsen et al.'s (1) work reported in PNAS (Fig. 1). Several more millennia would pass before a reliance on domesticated plants and animals became commonplace in both the Old and New Worlds.

Growing plants and tending animals increased yields per hectare, notably the caloric return, although doing so necessitated greater labor inputs and investments in the land itself. Settlement patterns and societal organization changed to accommodate new demands on labor, such as when planting, harvesting, and herding animals. While more food could be produced locally, much of it stored for lean seasons, agricultural economies were a mixed blessing. Diets became monotonous, and a narrower range of food courted disaster from failed harvests. More people packed together for longer periods increased the risk of disease from contaminated water, food, and soil. Social mechanisms, eventually greatly elaborated, developed to adjudicate disputes, dampening tensions that could tear communities apart. People had to defend themselves, their land, and stored food from neighboring groups because it was no longer easy to move away from sources of conflict. Variation in land quality and labor availability contributed to greater inequities among social groups than had ever existed before.

It is also widely accepted that agriculture exacted a steep price in human health, an idea that had its origin in separate research efforts decades ago. In the 1960s, studies of societies that pursued traditional ways of life showed that hunter-gatherers were not continually tormented by barely staying one step ahead of starvation. They were even considered the original affluent societies because of the plentiful food and leisure time they were said to possess (2). Archaeological skeletons examined in the 1970s and early 1980s were seen as indicating that health worsened, instead of improved, for early agriculturalists (3). Taken together, these research findings, along with information liberally borrowed from public health and disease ecology, were the basis for thinking that the establishment of agricultural economies inexorably led to greater morbidity and mortality, along with a host of societal problems (4, 5). The process occurred in 2 steps reminiscent of Rousseau's 18th-century musings on the subject. First, hunter-gatherers, who were initially well-off, were beset by various ills once they settled down and adopted agriculture. Second, the situation deteriorated even further when organizationally complex states first developed about 5 millennia ago.

A Questionable Model

The 2-step characterization of disease experience and evolving ways of life has some merit, but it also features empirical, logical, and methodological flaws. The exemplary Çatalhöyük work, while it parallels what has been found for early agricultural societies elsewhere, highlights some of the problems with an uncritical acceptance of the existing health-decline model.

Perhaps the most obvious difficulty with the current decline-in-health scenario is a lack of appreciation of cultural context, specifically what affected pathogen exposure and dietary quality. The Çatalhöyük work, in contrast, firmly places skeletal remains in their appropriate cultural context by drawing on diverse, but complementary, research efforts.

Years of excavations have identified how the community was laid out, along with changes over time in the local environmental setting and its relationship to animal husbandry practices. That allows multiple lines of evidence to be used when characterizing life at Çatalhöyük, increasing confidence in the research findings. For example, femoral shaft bending strength, which is responsive to habitual activity patterns, indicates long-distance travel

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Fig. 1. Many burials have been found at Çatalhöyük, such as this one being excavated, among building remnants, also shown. Image courtesy of the Çatalhöyük Research Project/Jason Quinlan.

when changes in the environment late in the occupation favored wide-ranging caprine herding. However, these animals must still have grazed in the surrounding area, rather than in distant pastures, to judge from the stable isotopic composition of their bones.

Living in crowded conditions in close association with domesticated animals meant that muck and filth choked passageways among closely spaced houses. In fact, traces of fecal matter, including parasite eggs, were found in buildings and nearby areas. The scale of pollution was related to the community's size, which had a peak population of several thousand. That puts Çatalhöyük at the upper end of early farming (or Neolithic) settlements elsewhere in the world, so in that respect it shared the problems of large towns in much later complex societies.

Children in Çatalhöyük suffered from repeated disturbances in the formation of their tooth crowns resulting in pits and grooves known as enamel hypoplasia. Presumably episodes of ill health were largely attributable to continuous contact with soil and water heavily contaminated with feces. These enamel defects are often seen in the skeletons of subsistence agriculturists elsewhere in the world, so the experience of the Çatalhöyük children was not at all unusual.

Other difficulties with the standard model include the use of overly broad societal categories and a unidirectional move toward ever-worsening conditions. Models are intentional simplifications of reality, but in the existing bioarchaeological literature the decline-in-health scenario is often merely trotted out to account for what is observed without further reflection on its applicability to specific cultural settings or how it can be refined.

The Çatalhöyük research shows that overly inclusive societal categories mask important variation in the societies included within them. Community size, caprine herding practices, and dietary intake changed over time. They are likely to have been related to differences in skeletal morphology attributable to mobility and disease, including bone lesions and tooth decay. Taking these signs of ill health at face value, conditions worsened from the early to intermediate period, but improved later on. Variation in activity and disease experience, along with the absence of a single directional trend over time, underscore the differences among societies lumped into broad categories such as agriculturalist. Understanding that variation, and the social and environmental circumstances that lay behind it, require intensive research commitments by multidisciplinary teams like the one assembled for the Çatalhöyük work.

The step-like model of universally declining health over time does not square with a global increase in the human population. If all agriculturalists and their later complex-society counterparts suffered so much from debilitating diseases, then one might question why populations in vast geographical areas, ranging up to entire continents and beyond, grew over the long run. Considered on a global level, this increase was exceedingly slow until recent centuries, with the upward tendency occasionally interrupted by historically and archaeologically documented downturns. By direct movement or through the adoption of their way of life, agricultural groups also proved to be remarkably successful at displacing hunter-gatherers from most places. Over the long run, agricultural economies proved to have a competitive edge that permitted their rapid spread, as seen from the perspective

of the entirety of our existence as a species. What is clear is that many people at Çatalhöyük suffered from diseases and disabilities, including severe cranial trauma that likely had behavioral consequences, for some time before they died. In that respect, Larsen et al.'s findings are similar to those of many other studies (6).

Research Challenges

How people who appear to have suffered so much were ultimately so successful is a puzzle that cannot be fully addressed without dealing with methodological limitations in the current practice of bioarchaeology. Two issues in particular—the effects of selective mortality on the composition of skeletal samples and the inaccurate and biased nature of adult age estimates—have been widely recognized for several decades as particularly intractable problems (7–9).

It is, of course, by necessity that bioarchaeologists focus their attention on skeletons. However, skeletons, a mortality sample, are not really what are of interest. Instead, one wants to understand the characteristics of living people, the communities that might be visited if one could somehow be transported back in time. The difficulty is essentially a sampling issue. People who died at each age are a biased sample of all who were once alive at that particular age. The skeletons examined tend to be from individuals who suffered from diseases or malnutrition, or who took part in hazardous activities. That bias makes the transition from counts of skeletal lesions in a mortality sample to the characterization of a living population an exceedingly difficult problem, although progress is being made to resolve this issue (10, 11).

Making sense of skeletal lesions in terms of the impact illnesses and injuries had on past populations is not possible unless better ways to estimate adult age are developed (juvenile age estimates are reasonably accurate). Conventional methods to assess the age of adults from their skeletons yield inaccurate estimates, especially from middle age onward (8, 12). Furthermore, the ages of people over about 50 y old are underestimated, and the uppermost part of the life span is captured only by age ranges spanning many decades or by open-ended intervals with lower bounds somewhere in middle age.

A Puzzling Picture

That returns us to the interpretation of the typical agriculturalist pattern where many pathological lesions are identified in skeletal collections. It is possible that these skeletons indicate that people simply lived with their diseases and disabilities longer than they did in groups where death, on average, came quickly before distinctive signs of the debilitating conditions had time to develop (9, 13). Tackling such issues requires effectively incorporating a mortality component into bioarchaeological analyses. It is then possible to estimate at a population level the cost of disease and trauma in lost years of life (14, 15).

We really do not know what took place that favored overall population growth once agricultural economies were established, even though many people were ill or disabled for lengthy periods before they died. Perhaps having sick people around was not as bad as might be imagined if they could still contribute to the community's welfare, and their lives were not much shorter than other villagers. Or maybe these people could be supported for long periods, at least during good times, by sedentary groups that had the capacity to produce and store food surpluses. All that can be said with certainty is that the situation was far more complicated, and at this point unknown, than the rather simplistic stepwise decline-in-health model would have us believe.

As nicely shown by the Çatalhöyük research team, the effects of the transition to agriculture—on body morphology as well as disease experience—were many and varied. They did not always head in the same direction because people were adapting to local and constantly changing circumstances. There is much that remains to be learned about the costs and benefits of the shift to agricultural economies, as well as the later evolution of organizationally complex societies. Answers are most likely to come about through multidisciplinary studies that focus on the specific characteristics of individual communities—the people and their surroundings—much like what has been done at Çatalhöyük.

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