Empirical evidence of the public health benefits of tropical forest conservation in Cambodia: a generalised linear mixed-effects model analysis

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See **Comment** page e164

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Summary

Background Potential synergies between public health and environmental protection that offer new opportunities for achieving health and sustainable development targets have been postulated. However, empirical evidence of the effect of ecosystem degradation and protection on public health outcomes is scarce, which restricts policy makers' ability to assess the net health effects of land-use change.

Methods We used generalised linear mixed-effects models to analyse data for 35 547 households in 1766 communities from the Cambodian Demographic Health Surveys to investigate the relation between health and protected areas across deforestation gradients in Cambodia between Feb 1, 2005, and April 30, 2014. Diarrhoea, acute respiratory infection, and fever in children younger than 5 years were used as population health indicators. Dense and mixed forest coverage were derived from Open Development Cambodia, and forest loss was calculated from 2000 to 2004, 2004 to 2009, and 2009 to 2014. The incidence of non-specific illness and injury in people older than 15 years was used as a negative control. Our analyses included rich pseudo-panel data (combining cross-sectional datasets from 2005, 2010, and 2014) that accounted for socioeconomic, demographic, and behavioural characteristics, and had a negative control, approximating a quasi-experimental study design.

Findings Deforestation of dense forest was associated with an increased incidence of diarrhoea (p=0·007), fever (p=0·0495), and acute respiratory infection in children (p=0·003). For example, a 10 percentage point increase in loss of dense forest was estimated to be associated with an increase of 14·1% (95% CI 2·6–35·8) in the incidence of diarrhoea in children younger than 5 years per household in the 2 weeks before the Cambodian Demographic Health Surveys. Protected area coverage, but not type, was associated with decreased incidences of diarrhoea (p=0·028) and acute respiratory infection (p=0·030). Apart from an association between mixed forest coverage and increased incidence of diarrhoea, forest coverage was not associated with any health outcomes.

Interpretation Deforestation is associated with increased risk of several major sources of global childhood morbidity and mortality. Although causal mechanisms are unclear, our findings suggest that protected areas could help to alleviate the global health burden, presenting new possibilities for simultaneous achievement of public health and conservation goals.

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Introduction

Diarrhoea, malaria, and pneumonia are leading contributors to the global health burden and caused nearly 2 million deaths in children younger than 5 years in 2013.[1] The Rockefeller Foundation–*Lancet* Commission[2] on planetary health emphasised the contribution of ecosystem degradation to this burden. Deforestation is a primary driver of global ecosystem change.[3] An estimated 1·5 million km² of forest were lost between 2000 and 2012,[3] and thus understanding the role of deforestation in health is essential in planetary health. Much of the emerging research linking deforestation and health is disease specific or vector specific. Such research is important for mapping high-resolution causal pathways, but integration of the evidence generated into policy could be challenging because the specific diseases that comprise the public health burden will change after landscape alteration. Empirical research is therefore required to assess the broad effects of ecosystem change across several conditions, supported by evidence of disease-specific mechanisms.[2,4]

The emerging One Health, planetary health, and ecohealth movements seek to transcend public health and environmental-protection boundaries to tackle collective challenges.[5] Identification of synergies and trade-offs between health and forest protection could offer new, cost-effective ways to jointly meet human and ecosystem health goals.[5,6] Protected areas are commonly used to limit forest loss and could help to mitigate the health effects of deforestation. Yet relations between protected areas and health are poorly understood, and could generate health costs and benefits that extend

Research in context

Evidence before this study
Important research gaps at the interface of public health and environmental management, including the effects of environmental alteration and protection on multiple health outcomes, have been identified. We searched Web of Science and SCOPUS with the search string "human health" AND "conservation" OR "protected area" AND "ecosystem" OR "deforestation" for articles published in any language on or before April 24, 2017. We also searched the reference lists of articles identified by our search. We omitted articles about land uses not associated with deforestation, those that did not include primary data, and those outside the scope of the research. Three studies were also omitted because of methodological concerns. Most studies of links between health, deforestation, and conservation focused on single diseases. Links between protected areas and several health outcomes were investigated in only two studies with empirical data. However, these studies were done at subnational scales.

Added value of this study
To our knowledge, we did the largest empirical analysis of links between deforestation, conservation, and several public health outcomes so far, with data from 35 547 households across deforestation gradients in Cambodia between 2005 and 2014. Our results address two key evidence gaps. First, most studies linking ecosystem change and health focus on single diseases. However, the relative proportion of diseases that comprise the total health burden is likely to change after environmental alteration. Within our study, dense forest loss was associated with increased rates of diarrhoea, acute respiratory illness, and fever in children, all of which are strongly associated with childhood mortality. Second, we respond to calls to identify potential win–win situations, whereby health and environmental goals are addressed by the same management actions. Our results suggest that protected area coverage was associated with decreased incidences of diarrhoea and acute respiratory illness.

Implications of all the available evidence
Our findings add to the growing body of evidence that deforestation, a major component of land coverage change worldwide, might increase the prevalence of several sources of global morbidity. Policy makers should consider these public health implications when assessing trade-offs in land-use planning. The role and cost-effectiveness of conservation in supporting human health remains uncertain. However, studies of the role of conservation in public health suggest that managing protected areas could help to achieve health and sustainable development targets.

beyond any mitigation of deforestation.[7] McKinnon and colleagues[8] reported that, of 1043 studies linking conservation and wellbeing, health outcomes were analysed in less than 2%. They concluded that links between conservation and health are understudied and should be researched further.[8]

Forest loss seems to be linked with increased malaria risk in Africa and South America, but a wide range of factors—including resultant land use, microclimatic characteristics, vector species, and human behaviour—mediate this relationship (figure 1).[9] For example, deforestation can increase local temperatures, creating surface water suitable for mosquito breeding and thereby increasing malaria risk.[10] Although a close link between deforestation and diarrhoea has been postulated in several studies,[11,12] it has yet to be systematically reviewed. Deforestation increases peak flows and erosion, reduces groundwater recharge and low flows,[13] and is often associated with agricultural expansion. These factors can increase microbial load and exposure, potentially raising the risk of diarrhoea in downstream communities. Deforestation might also be associated with respiratory illnesses through various mechanisms: fire is often used to clear tropical forests, and fine particulate matter from biomass smoke can penetrate deep into the lungs, thereby increasing the risk of respiratory infection (including pneumonia).[14] Overall, habitat disturbance can increase several disease risks by disrupting the hypothesised dilution effect, in which high host diversity is associated with decreased probability of zoonotic transmission.[6] Additionally, deforestation could also affect health through non-environmental mechanisms. For instance, dietary diversity was positively associated with tree coverage in 21 African countries.[15] Forest loss could therefore have adverse nutritional effects, which increase disease vulnerability, when people are not able to offset resulting dietary changes with increased food production or purchasing power.

The interactions between ecosystems and human health are complex and many (figure 1). Empirical analyses in which several diseases are assessed simultaneously are needed, and the potential role of protected areas in mitigating health effects needs to be elucidated. Our research responds to important gaps by investigating two questions: is deforestation associated with major causes of childhood morbidity, and do the type and coverage of protected areas reduce the risk of these causes? Cambodia faces persistent health challenges and rapid environmental change. Many tropical countries face similar health and conservation issues, and thus Cambodia is a suitable case study in which to explore these questions. The country is part of the threatened Indo-Burma biodiversity hotspot, and more than 60% of its dense forest was lost between 1973 and 2014;[16] much of the deforestation after 2002 was illegal.[17] Deforestation has been driven by agricultural expansion, large-scale development projects, and illegal timber harvesting compounded by poor institutional capacity, unclear land tenure, and restricted

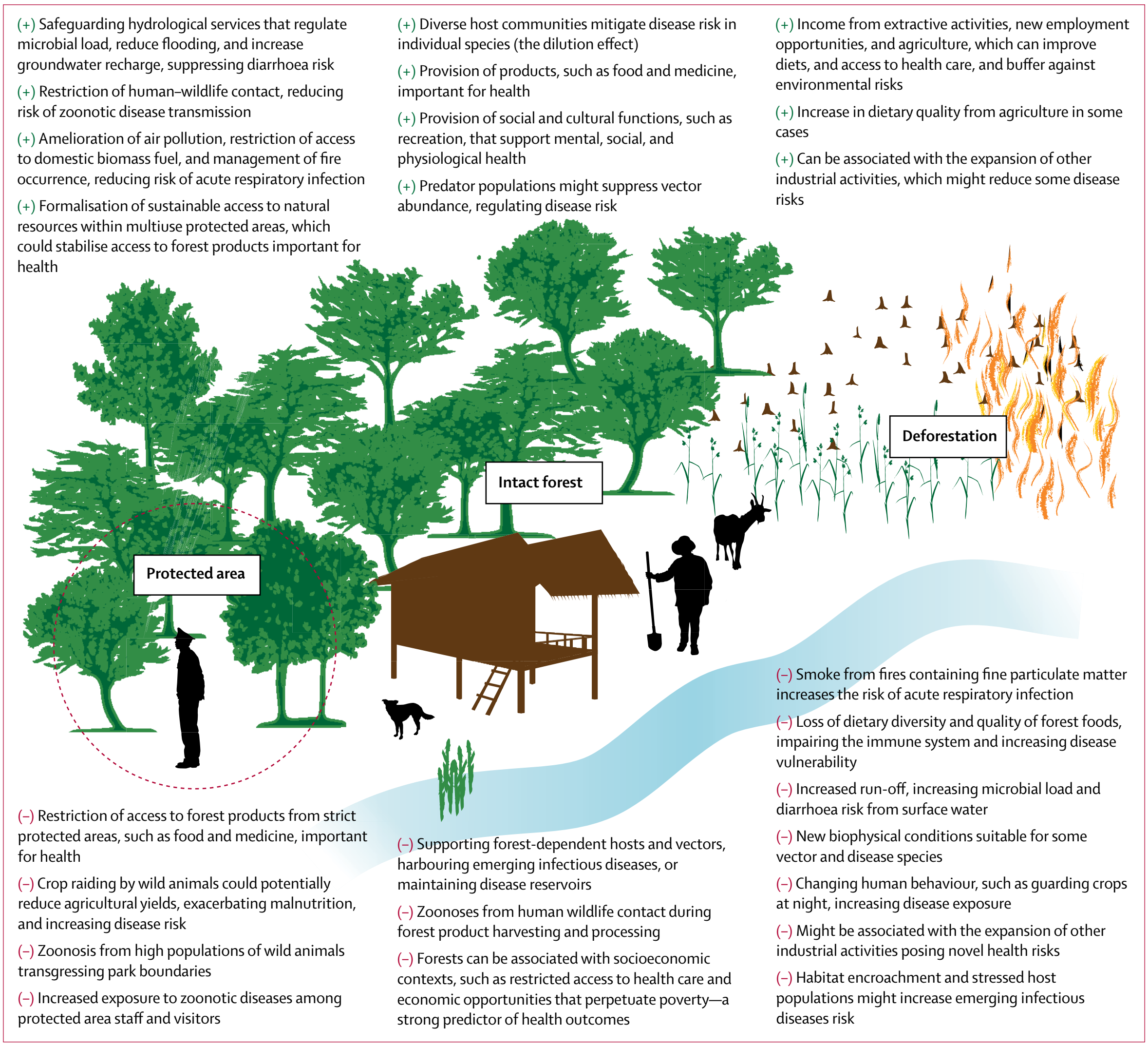

Figure 1: **Examples of potential links between protected areas, forest coverage, deforestation, and health**
Green plus symbols represent potential health benefits, whereas red minus symbols represent possible health threats. Some factors, such as changing diets, could have antagonistic health effects.

law enforcement.[18,19] In response to these pressures, 17% of Cambodia's terrestrial area has been designated as protected areas.[18] Much of Cambodia's roughly 80% rural population is dependent on agriculture and use forest resources for food and medicine,[20] and many of these protected areas contain existing settlements.[17] Despite rapid economic development, 20% of the population were below the national poverty line in 2011, and many health challenges persist.[21] According to data from 2014,[21] one in every 29 children does not survive to their fifth birthday, and 6%, 28%, and 13% of children had symptoms of acute respiratory infection, fever, or diarrhoea, respectively, in the 2 weeks before these data were gathered.

We used generalised linear mixed-effects models to investigate health outcomes in Cambodia across protected areas and forest coverage and loss gradients between 2005 and 2014. Our analysis was multiple scale, and included landscape-level spatial data and rich household-level socioeconomic data. We assessed relative health and land-use changes with time, and used a negative control in a quasi-experimental study design.

Methods

Household health and socioeconomic data

We used health data from the 2005, 2010, and 2014 Cambodia Demographic and Health Surveys (CDHSs),[21–23] which included 35 547 households in 1766 communities (figure 2). Households were systematically sampled within communities, which were probabilistically sampled on the basis of population size across Cambodia in 2005, 2010, and 2014. Data included socioeconomic and health outcomes in adults and children. The CDHS randomly dislocated most community locations by as much as 5 km to protect anonymity.

For more on the **details of methods for the CDHS** see http://www.dhsprogram.com

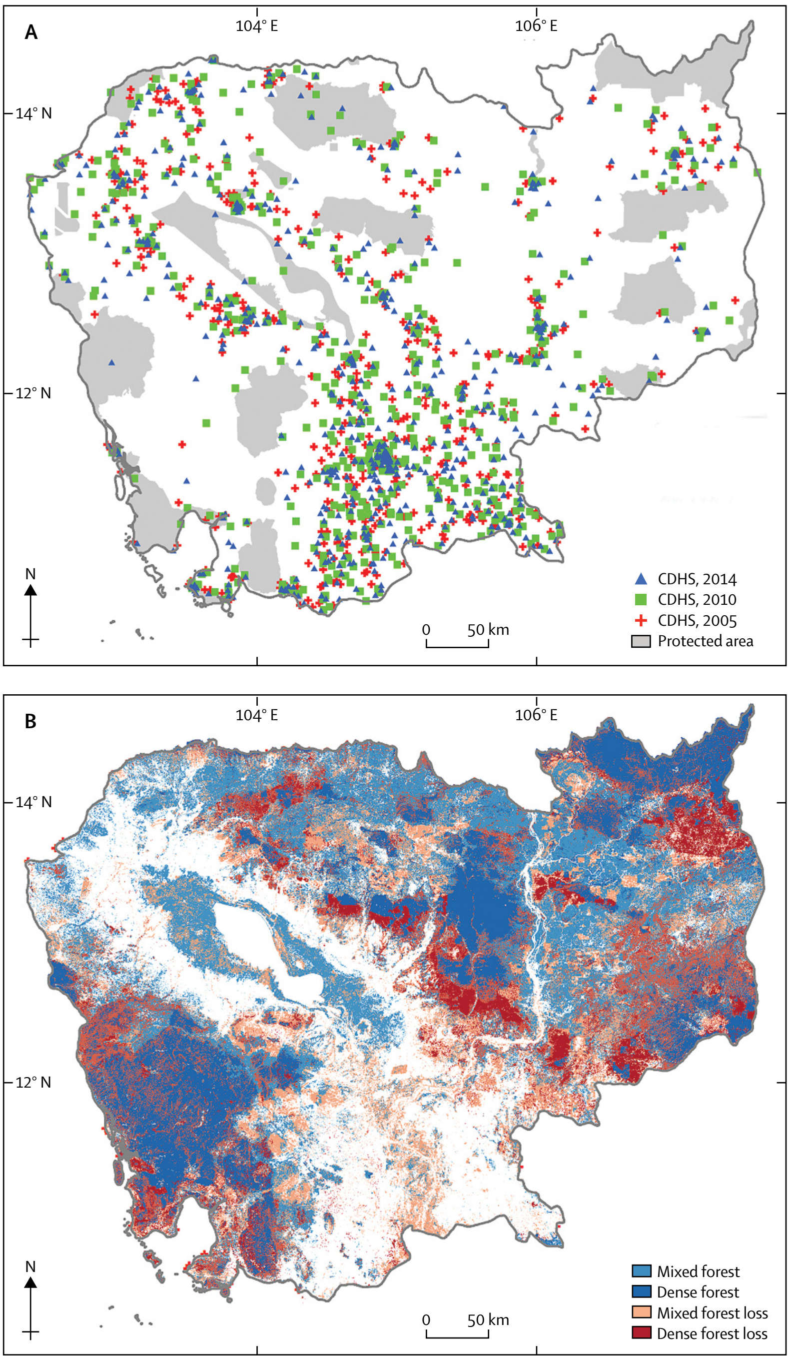

Figure 2: **Communities surveyed in the CDHS (2005, 2010, 2014) and protected areas (A), and dense and mixed forest coverage and loss (B)**
Forest coverage data are for 2014; forest loss data are for 2004–14. CDHS=Cambodia Demographic and Health Survey.

See Online for appendix

Diarrhoea, acute respiratory infection, and fever in children younger than 5 years were used as population health indicators by the CDHS and in our analysis. The incidence of non-specific illness and injury in people older than 15 years was used as a negative control. Covering all illnesses, including injuries and non-communicable diseases, we deemed general adult health to be less closely associated with ecosystem changes than diarrhoea, fever and acute respiratory infections. Malaria, lower respiratory tract infections, and diarrhoeal diseases combined contributed only 5·1% of disability-adjusted life-years from the top 100 causes of disease burden in adults aged 15–49 years in Cambodia in 2015.[24] Therefore, we expected general adult health to be strongly associated with socioeconomic characteristics but weakly associated with ecosystem changes, making it an informative negative control. Incidence of diarrhoea, fever, and acute respiratory infections in children during the 2 weeks before the CDHS, and of general adult illness and injury in the 30 days before the CDHS, among household residents was included in the analysis. Children's health data were aggregated when more than one woman participated from each household. We selected explanatory variables on the basis of relevant literature (appendix). The variables selected were number of children, number of adults, owned agricultural land (in hectares), water source, water treatment, sanitation (type of toilet facility), cooking fuel (biomass or non-biomass), cooking location (indoor or outdoor), smoking, mean adult age in each household (and the square of mean adult age), wealth (from asset indices), and location (urban or rural). All observations with complete data were included.

Geospatial data

Spatial data were obtained from Open Development Cambodia, a non-governmental organisation that compiles spatially explicit economic and developmental data on Cambodia.[16] Forest cover maps had 30 m×30 m resolution and were constructed by Open Development Cambodia from Landsat TM and Landsat 8 satellite images. Open Development Cambodia converted multiband raster images into a single composite band raster image, which was then classified into five forest-cover categories with maximum likelihood methods. Dense and mixed forests were defined according to *Forestry Administration's Cambodia Forest Cover 2010*.[16,25]

We delineated a 15 km buffer from the centre of each community to encompass spatial dislocations in the CDHS data. Areas outside Cambodia (affecting 8% of communities) and 13 non-georeferenced communities were excluded. We calculated the proportion of dense and mixed forest coverage and gross loss from Jan 1, 2000, to Dec 31, 2004, Jan 1, 2005, to Dec 31, 2009, and Jan 1, 2010, to Dec 31, 2014, and the protected area extent within the buffer regions (as a proportion of the absolute buffer size). Euclidean distances between community and urban areas (defined as those with >10 000 people) were measured, centred, and scaled. 23 existing protected areas during the study period were included in the analysis. Protected areas were grouped into three categories on the basis of how strictly they were managed according to the 2008 *Law on Nature Protection Area*.[26] These categories were national parks, wildlife sanctuaries, and multiuse protected areas, which corresponded to the International Union for Conservation of Nature categories II, IV, and V and VI (combined), respectively. The category of the protected area closest to each community was included as a variable in the analysis. A dummy level, “no protected area”, was included in this variable if there was no protected area within 15 km of a community.

Statistical analysis

Generalised linear mixed-effects models were fitted with the Poisson distribution and log link function. The log-transformed number of children or adults per household was used as an offset to account for differences in household size. A random intercept was created for each community and province to account for spatial dependency. Because households and communities were anonymised, health outcomes at these levels could not be tracked over time. However, we assumed that changes in health status were correlated over time within each province. Therefore, a random slope (year) was included to model the variation in changes in disease incidence over time for different provinces, thus creating panel members (units observed over time) for 2005, 2010, and 2014 at the provincial level. Global models for the four health outcomes were fitted. No model assumption violations were noted. Model residuals were slightly underdispersed, so CIs were likely to be conservative. 27 hierarchical candidate models were developed a priori for each of the four illnesses. Inclusion of socioeconomic, demographic, and behavioural factors varied among the four illnesses. For example, sanitation and water source characteristics were included when we modelled diarrhoea, and location and type of cooking fuel were included when we modelled acute respiratory infections. These socioeconomic variables were consistent within each illness’s candidate set (appendix). Choice of spatial variables, which varied within candidate sets, was informed by conceptual scenarios. Candidate models were ranked with the Akaike information criterion. No models had a Δ Akaike information criterion of greater than 2, and therefore model averaging was done across the entire candidate set.

In addition to the primary analyses, we explored the relations between protected areas, forest coverage, and forest loss to help separate the effects of protected areas from those of deforestation (appendix). In this additional analysis, forest and protected area variables were dropped to test the sensitivity of the results and model fit (appendix). Bootstrap CIs (1000 simulations) were also calculated for the models with the lowest Akaike information criterion to assess the robustness of our results. We used R for all statistical analyses.

Role of the funding source

The study funder had no role in study design; data collection, analysis, or interpretation; or writing of the Article. TP had full access to all study data and had final responsibility for the decision to submit for publication.

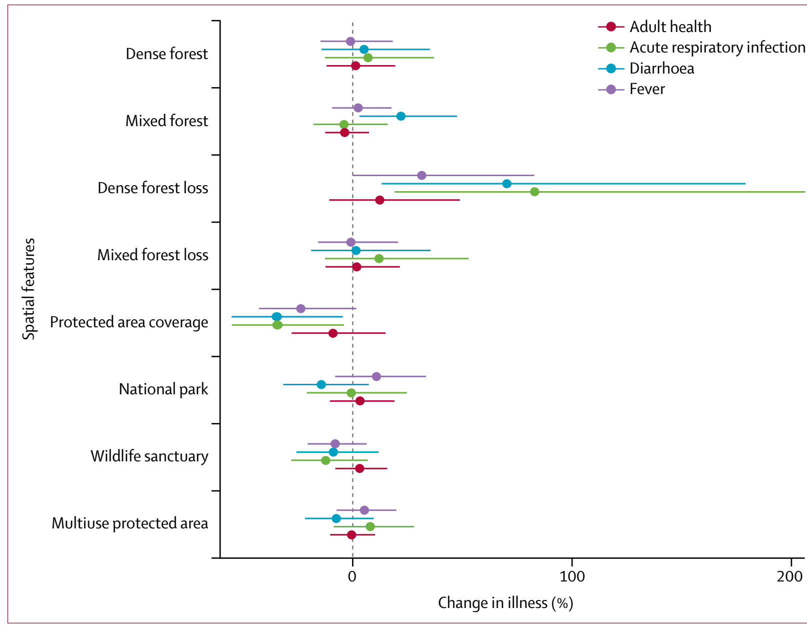

Figure 3: **Effects of forest coverage and loss and protected area coverage and type on incidence of acute respiratory infection, diarrhoea, and fever in children, and overall adult health**
Data are point estimates and 95% CIs associated with a 50 percentage point increase in forest coverage and forest loss or a 100 percentage point increase in protected area coverage within the 15 km buffer regions around communities. Also included are point estimates and 95% CIs associated with type of protected area within 15 km of each community (the reference level is “no protected area”).

For more on **Open Development Cambodia** see https://opendevelopmentcambodia.net

Results

Loss of dense forest within buffer areas in the 5 years before each CDHS was positively associated with increased frequency of diarrhoea (p=0·007), acute respiratory infection (p=0·003), and fever (p=0·0495) after socioeconomic characteristics were controlled for (figure 3). For example, a 10 percentage point increase in loss of dense forest within buffer areas was estimated to be associated with an increase of 14·1% (95% CI 2·6–35·8) in the incidence of diarrhoea in children younger than 5 years per household in the 2 weeks before the CDHS. Greater protected area coverage was associated with decreased frequency of diarrhoea (p=0·028) and acute respiratory infection (p=0·030), but not of fever (p=0·064; figure 3). For example, a 10 percentage point increase in protected area coverage within buffer areas was estimated to be associated with a 3·5% (95% CI 0·5–5·5) decrease in the incidence of diarrhoea. The type of protected area was not significantly associated with any health outcomes (figure 3). Adult health was not significantly associated with forest loss or cover, or protected area variables.

Distance from communities to urban areas, dense forest coverage, and loss of mixed forest within buffer areas were not significantly associated with incidence of any illness (appendix). Mixed forest coverage was positively associated with the incidence of diarrhoea but not of the other illnesses (figure 3). The association between socioeconomic variables and health was generally consistent with our expectations—ie, that improved socioeconomic status and living standards were associated with better health (appendix). For example, the richest households were estimated to have a 17·4% (95% CI 5·6–27·7; p=0·005) lower incidence of diarrhoea (in children younger than 5 years in the 2 weeks before the CDHS) and a 39·5% (95% CI 31·7–46·5; p=0·001) lower incidence of general adult illness and injury than the poorest households when all other variables were controlled for. Additionally, the incidence of all illnesses declined between 2005 and 2014 (appendix).

Our analysis included 9148 incidences of diarrhoea (in 19 231 households), 10 327 incidences of fever (in 19 083 households), and 6295 incidences of acute respiratory infection (in 14 996 households) in children in 2005, 2010, and 2014. 14 429 incidences of moderate to severe illness or injury in adults were recorded in 31 435 households. Household and community level descriptive statistics for variables included in the analysis are in the appendix. Protected area coverage was associated with higher rates of deforestation of dense and mixed forest, especially from national parks, compared with unprotected areas. Protected area coverage, particularly national parks and wildlife sanctuaries, within community buffers was also associated with higher dense and mixed forest coverage (appendix). The association between loss of dense forest and health was consistent when protected area coverage and type were excluded (appendix). The correlation between protected area coverage and health outcomes became less significant when dense and mixed forest coverage and loss were excluded from the models (appendix). Nonetheless, the models did no better, and often worse, when protected areas and forest variables were excluded from the analysis (appendix). Bootstrapped CIs were consistent with our primary results (appendix).

Discussion

Our study of conditions related to major causes of childhood morbidity and deforestation (a driver of global ecosystem change) responds to calls for empirical research exploring the effects of land-use change on combined health outcomes. We identified potential policy-relevant synergies between public health and environmental protection. Loss of dense forest was associated with increased incidences of diarrhoea, fever, and acute respiratory infection in children. The coverage of protected areas, but not the type, was associated with lower incidences of diarrhoea and acute respiratory infection, but not of fever. Apart from a positive association between mixed forest and diarrhoea, forest coverage was not associated with any health outcomes. Adult health, the negative control, was not associated with forest coverage or loss, or protected area coverage or type.

Our findings support hypothesised links between deforestation and health (figure 1). For example, Pattanayak and Wendland[11] argued that forest loss can disrupt water-regulation cycles, which increases microbial load, leading to greater risk of diarrhoea in downstream communities. More than 35% of Cambodia's rural households source their drinking water from unprotected wells, springs, and surface water, and only 67% of households used appropriate water-treatment methods before drinking.[21] A study[27] in the Kandal province of Cambodia showed that *Escherichia coli* concentrations in pretreated water far exceeded WHO recommendations for maximum safe levels in drinking water. This finding suggests that the population could be vulnerable to disruption of hydrological services by deforestation. Cambodia's predominantly rural population could also be vulnerable to the effects of deforestation on malaria risk, a major cause of fever. There are many pathways linking deforestation and malaria.[9] For instance, deforestation can create hotter microclimates, increasing mosquito vectors' reproductive rates and potentially heightening malaria risk.[10] Deforestation can also be associated with changing reservoir species' behaviour and greater human exposure.[28] By contrast, the relation between deforestation and acute respiratory infection might be less dependent on intermediate ecological processes. Biomass smoke increases the incidence of respiratory illness, and 15 600 child, infant, and fetal deaths were attributed to poor air quality after forest fires in Indonesia in 1997.[29] Fire is used in both small-scale and industrial forest clearance in Cambodia, and could have increased the risk of acute respiratory infection in children.

Forest loss might also be linked to health through socioeconomic pathways. Forest products are an important source of food in Cambodia, especially for the poorest populations.[20] Deterioration of dietary quality after deforestation could increase disease susceptibility, particularly among vulnerable groups, such as people living in poverty. Large-scale land acquisition is a major driver of deforestation. Forest loss was 29–105% higher in economic land concession areas, a mechanism for selling or leasing state land to investors, than in matched counterfactuals between 2000 and 2012.[19] These procurements were often associated with loss of access to natural resources and evictions.[30] Thus, land acquisition can disrupt the provision and accessibility of health-related ecosystem services. By contrast with specific local effects of deforestation, national health outcomes improved with time during the study period, which might be partly attributable to economic development derived from exploitation of natural resources. Thus, the health costs should be weighed against the benefits of industrial expansion in assessments of the net health effects of deforestation.[31]

Forest coverage was not significantly associated with health, apart from the correlation between mixed forest coverage and a slightly increased incidence of diarrhoea. Because our analysis differentiated only between forest and non-forest, and did not account for the health effects of other types of land coverage, the effects of forest coverage might be obscured. Furthermore, behavioural and technological adaptations to environmental risks, such as the use of mosquito nets, can develop in established forest communities but might be slow to emerge in response to rapid deforestation. Although these communities might exploit forest resources in times of illness or economic stress,[32] isolation from modern health care and economic prospects will worsen health outcomes.[33] Our analyses suggest that socioeconomic status has a more distinct association with health than proximity to forest. These results have parallels with findings that suggest that wealth and urbanisation were strongly associated with health in 60 medium-sized countries but forestation was not.[34]

Our results linking protected areas and health are broadly consistent with those of the few other studies of this topic. Strictly managed protected areas in Amazonia seem to have reduced biophysical disruption from deforestation and restricted people's exposure to disease sources, which might have reduced the incidence of malaria, acute respiratory infections, and diarrhoea.[12] Protected areas in Indonesia might have protected forests that regulate water quality, thereby reducing the incidence of diarrhoea in nearby communities.[11] Conversely, proximity to protected areas, which retain greater forest coverage suitable for malaria vectors than unprotected areas, might have increased malaria risk in Brazilian cities,[35] but there were concerns about the methods used in this study, including failure to account for some demographic changes.[36,37] Our results support findings of the positive association between protected areas and health. Protected areas and forest coverage were positively correlated within community buffers (appendix), but the community buffer areas that contained greater protected area coverage had greater absolute forest loss. This result could be explained by the displacement of deforestation to areas outside of park boundaries. Nevertheless, these results suggest that protected areas did not affect health through the prevention of deforestation—other behavioural and socioecological factors could account for the correlation between protected areas and health. Protected areas could have restricted human–wildlife contact, reduced zoonotic disease exposure, or protected ecosystem services that were independent of deforestation.

Protected areas are also associated with institutional and socioeconomic health factors. Clements and colleagues[30] reported that Cambodian resin harvesters in protected areas were better off and had higher rice yields than those outside. They argued that protected areas could have stabilised land access and reduced selective logging of economically important trees, which cannot be detected by satellite maps of deforestation. The health of residents could have been supported by improved socioeconomic conditions and natural-resource access within these protected areas. In our study, we did not find a significant association between the type of protected area and health. Protected area category might have been a poor measure of actual conservation management. Overall, these results suggest that processes beyond deforestation affect the role of protected areas in health in Cambodia, although these mechanisms remain speculative, and require further research.

Our analysis accounted for local heterogeneity and spatially dependent bias but was constrained by a paucity of data. Regrettably, data for mosquito net ownership and use, household hygiene, forest use, forest type, human migration, and adaptive behaviour were not available. Additionally, the accuracy of self-reported health outcomes is likely to be affected by under-reporting, misdiagnosis, and recall bias. We therefore did not estimate national disease incidences. We also used a random-effects structure to account for spatially dependent differences in reporting, and calculated bootstrapped CIs to test sensitivity to reporting error. However, the strength and direction of possible bias are unknown, which is a limitation of our analysis. The dislocation of communities by the CDHS reduced the accuracy of forest coverage and loss estimates, but the direction and distance were random so we do not expect it to have introduced bias to our analysis.

Adult health was not associated with deforestation, forest coverage, or protected area variables. As a negative control, it was included to ensure that important health factors associated with deforestation gradients were not omitted from the analysis. We anticipated that adult health would be weakly associated with deforestation—because it covered all illnesses, including non-communicable diseases, was not limited to diarrhoea, acute respiratory infection, and fever (which account for only a small share of the adult disease burden), and was only partly dependent on child health as a result of intrahousehold transmission—but more strongly associated with socioeconomic characteristics. Furthermore, our results were robust to the removal of protected area and forest variables, suggesting that our analysis was not sensitive to related spatial dependencies.

The Rockefeller Foundation–*Lancet* Commission on planetary health identified key challenges, including limited transdisciplinary research, which need to be addressed to improve human health in the face of rapid ecosystem degradation.[2] Our research contributes to efforts to overcome these challenges by providing empirical evidence of the negative effect of deforestation, a major source of global environmental change, on leading causes of childhood morbidity. Similar to Cambodia, many other tropical countries face substantial threats to health and forest ecosystems, and have restricted conservation capacity. Our results support the role of protected areas in Cambodia, but also suggest a need for further research into the mechanisms linking conservation management and health. Social, economic, political, and biophysical factors make the simultaneous attainment of different goals difficult, and the relationship between protected areas and people has often been challenging. Exploration of which aspects of conservation management are beneficial or deleterious to health, and how these aspects can be optimised and operationalised in a multiple objective context, will be essential if conservation is to make meaningful public health contributions.[7] Although the mechanisms linking conservation and health need clarification, our results strengthen the case for environmental protection as a tool to help reduce global disease burden.

Contributors

TP did the data collection and analysis. All authors contributed to study design, interpretation of the results, and the writing and revision of the Article.

Declaration of interests

We declare no competing interests.

Acknowledgments

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