Health impact assessments driven by classical epidemiological-based models: how reliable are our predictions in systems with feedback? A qualitative dynamical systems assessment

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Background and aims: Scenario-based health impact assessment s– such those used to estimate future climate change impacts – are commonly driven by static equations fitted to observed conditions. When using these equations, variable values are changed to reflect scenario conditions, with equation coefficients remaining constant. However, when modelling systems with feedbacks or subject to perturbations, a change of variable value or context may percolate through the system leading to a change in the equation coefficients. In these cases, a static equation may not correctly predict outcomes under scenarios of interest. We use a qualitative dynamical systems approach to demonstrate this.
Methods: We analyse a previously developed regression equation that quantifies the relationship between weight gain, energy intake, and disease. The equation was fitted in a stable setting and then used to estimate population weight gain under various scenarios. Using this framework, we developed a dynamical system incorporating feedbacks. When possible, we quantified relations; when not, we represented them qualitatively (e.g. directionally). We then perturbed the system in various ways and assessed the impact on the coefficients of the original regression equation.
Results: The dynamical model showed that under certain perturbations, the system shifts and settles at a new equilibrium. When this occurs the correlations between the system variables - which represent the coefficients of the original regression equation – also change. This suggests that beyond the situation in which the regression equation was fitted, it does not correctly predict the outcome
Conclusions: This paper has shown that in systems subject to feedback or perturbations, it may not be appropriate to model health impacts under given scenarios using static equations. Additionally, in some situations, qualitative knowledge of relations is sufficient to gain insight into system behaviour and can guide the development of quantitative models.