can provide standards for comparison in some states.

## CONTINUED CHALLENGES

The foundational steps described in the two articles mentioned previously are necessary but not sufficient to establish EHR-based surveillance systems at this time when public health resources are under stress. Both author groups note that their EHR-based surveillance systems are cost effective. That may be true after the systems are set up and validated, but many jurisdictions may have difficulty finding the resources to replicate this work. State and local health departments have received only a fraction of the resources that the clinical sector received under the HITECH meaningful use program. More resources will be needed to fully establish EHR-based surveillance systems.[7] Continued collaboration between public health and clinical settings, which can access HITECH resources, will also be critical.

EHR-based surveillance is still in its infancy. Perlman et al.[3] and Klompas et al.[4] show the way forward. However, replicating their models across the country will be challenging. Standardizing methods and algorithms and sharing technological solutions will certainly be helpful. However, for EHR-based surveillance to become a reality, the public health community must stay involved and must advocate for crucial resources. **AJPH**

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# Complexity in Public Health Research: A Public Health of Consequence, September 2017

In this issue of *AJPH*, Marshall considers the application of systems science approaches to population health.[1] Consideration of these models for population health rests on the recognition that populations are complex, dynamic systems characterized by long-tail effects, reciprocities, discontinuities, and emergent properties.[2] Marshall suggests that systems science approaches can help a public health of consequence in pushing scientific boundaries, nudging forward the questions we ask, and grappling with the multifactorial and multisectoral processes that produce many public health challenges. We agree and see Marshall's editorial as an important reminder of the potential of analytic methods that have largely been outside the mainstream of population health science analysis. Saliently, this editorial coincides in this issue with four articles that very much reinforce Marshall's point about the importance of considering population health through a complex systems lens.

## LONG-TAIL EFFECTS

Two articles in this issue illustrate the long-term consequences of particular exposures, reminding us that too narrow a focus on the immediate could allow us to miss important factors and consequences that shape population health. Acquah et al. consider a long-ago exposure indeed: in utero exposure to the 1918 flu pandemic.[3] Using data from the Asset and Health Dynamics survey, a nationally representative sample of persons born in 1923 or earlier, they found that in utero exposure to the deadly wave of the 1918 influenza pandemic increased the number of hospital visits for persons older than 70 years by 9.9 per 100 persons. For those exposed in utero to the deadliest wave of the influenza pandemic, high rates of activities of daily living limitations were related to

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higher rates of hospital visits in older age.

This study illustrates a remarkable long-tail consequence, more than 70 years in the making, of a population-wide phenomenon, in this case the 1918 flu pandemic. The authors suggest that long-term hospitalizations need to be considered in cost–benefit evaluations of vaccinations. We agree and would go a bit further to suggest that we need to generally consider the long-tail consequences of population-wide events both in considering the weight we need to place in the immediate present on mitigating the consequences of these events and on thinking about the causal architecture that has shaped the present of population health.[4]

A second article makes a similar point, albeit with a shorter time frame. Winter and Sampson were interested in documenting the relations between childhood lead exposure and mental, physical, and behavioral domains of adolescent health.[5] Using data from a random sample of participants in the Project on Human Development in Chicago Neighborhoods, they show that childhood lead exposure is associated with adolescent wellbeing. In particular, they show that a one microgram per deciliter increase in average childhood blood lead level was associated with 0.06 and 0.09 standard deviation increases and a 0.37-point increase in adolescent impulsivity, anxiety and depression, and body mass index, respectively. These are, again, classic long-tail effects that show how exposure at one point in time can be an important determinant of population health decades later.

Winter and Sampson also point out that the racial/ethnic patterning of initial exposure can have implications for the subsequent patterning of the long-term outcome. This has implications for exposure to lead, generally patterned on poverty and minority race in the United States but also on exposure to infectious agents in utero that can depend on particular social networks and access to preventive measures.

Both of these articles effectively make the point that considering the complex dynamic system that is population health needs a full consideration of drivers both proximal and distal. This requires us, at the very least, to ask questions through a systems science lens, adopting whatever analytic methods are appropriate to better understand the phenomena so that we can mitigate the consequences of adverse exposures.

## MACROLEVEL INFLUENCES

In another article, Yimgang et al. used data from Children's HealthWatch, an ongoing cross-sectional study, to assess whether exposure to civil unrest following Freddie Gray's death in Baltimore was associated with maternal mental health.[6] The article documented an acute period of elevated depressive symptoms in the five months after the period of unrest, more likely in those mothers close to the event, and mediated by concern about community activities. This article also reminds us, however, that the drivers of population health are multiscale and related to complex societal processes.

The article shows how difficult it is to consider individual health in isolation from contemporary stressors and agitates

for a full understanding of the causal architecture of population health. One might well expect that there will be long-tail consequences of maternal mental health that would then bring together both the macrolevel influences and distal consequences being discussed here.

## FEEDBACK

Finally, Light et al. demonstrate the potential feedback that emerges from undocumented immigration and its relation to other aspects of legal involvement.[7] In a time of heated political discussion on undocumented immigration, it is fair to suggest that the notion of "undocumented" is freighted with negative connotations in the broader public conversation. Light et al., however, ask whether undocumented immigration is associated with better or worse indicators of drug and alcohol problems, including drug arrests, drug overdose fatalities, and arrests and deaths related to driving under the influence.

They found that undocumented immigration is significantly associated with lower drug arrests, drug overdose deaths, and driving under the influence arrests, after controlling for other factors in a state-level analysis. The authors discuss the mechanisms that can explain this function, including, centrally, that undocumented immigrants may be less likely to use drugs, fearing encounters with law enforcement. This is a classic example of feedback in a case in which the group's defining characteristic, in this case having an issue in the legal domain, improves the group's engagement in other domains as well as a reminder of the complex forces

that shape population behavior and population health.

Contributions to this issue of *AJPH* aptly illustrate the complex forces that can shape population health. If we are to call for and promote a public health of consequence, we cannot simply advocate the same frameworks and analytic approaches and expect the creation of potentially disruptive knowledge. We need to highlight the importance of using an analytic lens that is alert to long-tails, macrolevel influences, and feedback (among other things), all of which may inform population health. AJPH

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