



Environmental observation, social media, and One Health action: A description of the Local Environmental Observer (LEO) Network

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ABSTRACT

As a result of the close relationships between Arctic residents and the environment, climate change has a disproportionate impact on Arctic communities. Despite the need for One Health responses to climate change, environmental monitoring is difficult to conduct in Arctic regions. The Local Environmental Observer (LEO) Network is a global social media network that recruits citizen scientists to collect environmental observations on social media. We examined the processes of the LEO Network, numbers of members and observations, and three case studies that depict One Health action enabled by the system. From February 2012 to July 2017, the LEO Network gained 1870 members in 35 countries. In this time period, 670 environmental observations were posted. Examples that resulted in One Health action include those involving food sources, wild fire smoke, and thawing permafrost. The LEO network is an example of a One Health resource that stimulates action to protect the health of communities around the world.

1. Introduction

Subsistence activities (such as hunting and gathering), transportation, and community infrastructure in the Arctic are dependent on environmental conditions, leading to a close relationship between Arctic residents and the environment. Rapid environmental changes, such as those resulting from climate change and anthropogenic contamination, can present health threats to these communities [1,2]. In Alaska, shifts in species range, coastal erosion, thawing permafrost, and seasonal weather fluctuations are changing the health exposures of humans and animals [3,4]. These emerging issues fit into the One Health paradigm, which is the concept that human, animal, and environmental health are closely linked [5].

Innovative approaches are necessary to address the health needs of small, isolated communities like those in the circumpolar north. Given the extensive nature of the environmental changes occurring in the Arctic, One Health approaches that link community members to each other and to public health, veterinary, and environmental experts are essential. In many settings, One Health implementation has focused on zoonotic infectious diseases and antimicrobial resistance with less

attention to the environment, which represents a considerable gap in One Health practice [6–10]. The potential health outcomes resulting from environmental changes in Alaska necessitate a comprehensive approach that includes all three One Health domains.

Alaska encompasses a large geographic area with little infrastructure, making it difficult to monitor potential One Health issues. Citizen Science, defined as a collaboration between scientists and the general public to collect data, has been used in several contexts for environmental monitoring [11–13]. The citizen Science approach has been found to increase the breadth of scientific evaluation, allowing scientists to reach areas that would otherwise be inaccessible [14,15]. Social media has provided even further connectivity and potential for Citizen Science collaboration in remote and developing areas [16].

The Local Environmental Observer (LEO) Network is an environmental observation platform based within a social network, which started in Alaska in 2012 [17]. The platform links community members to each other and to experts in a responsive community engagement network to report and discuss environmental events. Here, we describe the processes of the LEO Network and frequencies of environmental observations between February 2012 and July 2017. We also illustrated

Abbreviations: LEO, Local Environmental Observer; ANTHC, Alaska Native Tribal Health Consortium.; CEC, Council on Environmental Cooperation.; BOEM, Bureau of Ocean and Energy Management.; EPA, US Environmental Protection Agency.

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the One Health action of the network by outlining three case studies.

2. LEO network process

In 2012, the Alaska Native Tribal Health Consortium (ANTHC) Center for Climate and Health in Anchorage, Alaska established the LEO Network web platform (www.leonetwork.org) to allow tribal health workers and local observers to share information about environmental change. Development of a mobile application as a remote reporting tool followed in 2015. Primary funding for LEO Network has been provided by the US Environmental Protection Agency (EPA), the Council on Environmental Cooperation (CEC) and the Bureau of Ocean and Energy Management (BOEM). The objectives of LEO are a) to collect observations (“Observations” hereafter) in space and time to show patterns in environmental change as it relates to human and animal wellbeing, b) publish a record of those Observations, and c) connect observers to each other and to technical resources.

The components of the LEO Network are as follows:

LEO HUBs

One of the important features of LEO Network is the ability for observers to connect with topic experts and discuss specific Observations. To facilitate these connections, the network incorporates regional “Hubs”; organizations, which provide support including editing, translations, training and consult referrals. LEO staff regularly communicate between Hubs to identify emerging trends, foster partnerships, and connect members.

LEO Network Members

Although the LEO Network originated in Alaska, participants can join from anywhere in the world. Each participant first creates a member profile including their community, affiliated organizations (usually tribe, school, or place of employment), and general topics of interest, such as fish, birds, human health, or others. Members are also asked about their primary, secondary, and tertiary environmental knowledge influences: scientific, local (based on living in a particular place) or indigenous knowledge. Participants can engage in various roles, including observer, consultant, project lead, editor, or translator. Members are organized by location-based community or organization (eg. research institution). Any member can write an environmental Observation in the system, and members can message each other privately through a secure messaging system.

LEO Network Observations

Fig. 1 shows the process involved in posting an Observation to the LEO Network. First, members describe their Observation in a written

narrative, often with pictures, and assign a category tag (weather, waters, fish, land air, invertebrates, health, insects, land mammals, microbes, pets, seasons, infrastructure, ocean, transportation, plants, sanitation, sea mammals, ice and snow, birds, other). LEO coordinators assess whether an Observation is appropriate to post based on six criteria, including whether it is time- and location- specific, whether the event was witnessed, if the event was significant, whether the Observation includes all the basic content needed, whether it is professionally appropriate, and whether it is respectful of personal information, privacy and the general membership. If an Observation does not meet the criteria, the LEO coordinators contact the observer to request more information.

LEO coordinators select subject area experts as consultants who respond to each Observation. LEO coordinators also add further resources and information in the form of on-going research projects, or published information. After the LEO coordinators or consultants respond to the Observation, it is posted to the network and to other social media outlets. Other members also have the ability to comment on Observations to LEO coordinators. These comments may provide additional information on the current Observation, in which case the commentator would become an additional contributor. LEO members can create personal collections of Observations using a personalized map feature. This allows individuals to explore trends and events that are of a particular interest to them.

LEO Network Projects

Observations can be collated into Projects (a group of Observations), which help focus on specific types of environmental change, specific locations of changes, or in specific communities. Projects can be initiated through two mechanisms. First, LEO coordinators can identify several Observations on related topics and create a Project to collect the Observations and provide additional information about them. The editors will then request that topic area experts serve as Project lead or consultants. In other instances, Projects are created at the request of a scientist or topic area expert who is interested in having LEO Network members make Observations on specific topics. As the Project develops, the collections of Observations are reviewed for emerging or existing trends.

3. Characteristics of LEO network members and observations

As of July 2017, the LEO Network had 1870 members in 35 countries (Table 1). The majority of members categorized themselves as having local expertise (991, 53%) and as observers (787, 42%). The United States, Canada, and Mexico had the highest numbers of members (Table 2). Approximately one quarter to one third of members in each country posted Observations. Between February 2012 and July 2017, 670 Observations were posted by members and disseminated by

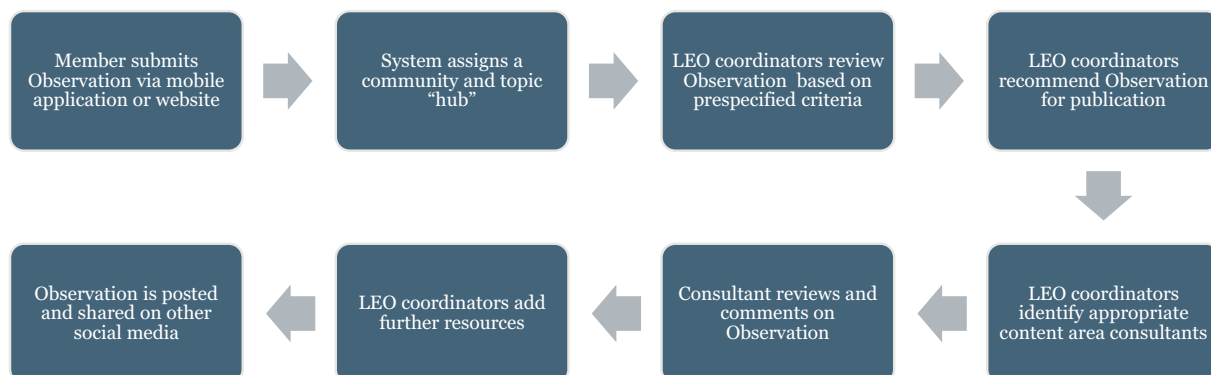


Fig. 1. Process flow for posting Observations to the Local Environmental Observer (LEO) Network.

Table 1
Descriptive characteristics of Local Environmental Observer (LEO) Network members, 2012–2017.

	Members N(%)
Total	1870 (100%)
Knowledge base ^a	
Local	991 (53%)
Science	856 (46%)
Indigenous	384 (21%)
Post role	
Observer	787 (42%)
Consultant	339 (18%)
Project Lead	56 (3%)
Other ^b	47 (3%)
None ^c	641 (34%)

^a Members could have more than one knowledge base.

^b “Other” could include editors or translators.

^c Members with no role are those that did not yet interact with a post.

Table 2
Observation posting among countries^a with over 50 Local Environmental Observer (LEO) Network members.

Country	Members (N)	Mean (SD) Obs per member	N(%) members with ≥ 1 Obs
United States	1049	0.91 (3.2)	323 (31%)
Canada	206	0.51 (2.8)	51 (25%)
Mexico	57	0.39 (1.0)	13 (23%)

^a Out of 35 total countries.

Table 3
Local Environmental Observer (LEO) Network Observations by year, 2012–2017.

	2012	2013	2014	2015	2016	2017 ^a	Total
Observations	55	76	98	115	266	87	697
Categories (n) ^b	18	21	18	24	26	22	28
Responses per post, median	1	1	1	2	1	1	1

^a Until July 2017.

^b Categories include: Health, weather, waters, fish, land air, invertebrates, insects, land mammals, microbes, pets, seasons, infrastructure, ocean, transportation, plants, sanitation, sea mammals, ice and snow, birds, other.

the LEO coordinators (Table 3). Fig. 2 shows the global distribution of Observations, the majority of which were posted in the United States (616 Observations, 92%).

4. One Health case studies

4.1. One Health case study 1: black fungus on smelt

4.1.1. Observation

In November of 2015, an observer in a village in the Yukon-Kuskokwim Delta wrote a narrative description of a recently caught smelt (a species of small fish that is commonly consumed by humans and other animals) that had unusual black markings. The Observation included pictures of the markings on the fish and the location that the fish was caught [18].

4.1.2. Response

Four consultants advised on this Observation. The Alaska Department of Fish and Game explained that the markings were a result of an infection with the fungus *Phaeohiphomyces*, which normally occurs in saffron cod. A consultant from the Fish Pathology Laboratory

in Anchorage then described the potential human health outcomes from this infection. He outlined the potential for infection among persons with immunosuppression and the potential for allergenic threat, ultimately advising that these fish not be consumed. The consultants provided information on the clinical signs of infection in fish, transmission of the fungus, and contact information for the Alaska Fish Pathology Laboratory. The LEO Network alerted the local health corporation, marine advisory agents, and environmental health staff of the Observation. The Observation was added to three Projects, including a Project with One Health relevant content, a Forage Fishes of the Northeast Pacific Project, and a Fish Illness Project.

4.1.3. One Health implications

In this interaction, the observer and the LEO Network team identified a pattern of a potential human pathogen in a food source. *Phaeohiphomyces* infections in fish are considered an emerging disease which result from metabolic factors, stress, poor water quality, trauma, or other infections [19]. *Phaeohiphomyces* infection in humans has been reported among immunocompromised persons and, rarely, in immunocompetent persons [20,21]. The LEO Network connected the observer to experts in fish pathology and human health, while providing timely advice to avoid consumption of these fish. The LEO Network also informed other network members and relevant agencies in case scientific or public health follow-up was warranted.

4.2. One Health case study 2: fire smoke encroaching into Unalakleet

4.2.1. Observation

In June 2017, an observer in a village on the coast of Alaska noted a haze in the nearby hills to the north and the east, with a smell of burning wood. The observer provided photographs of the haze at the time of the initial Observation and then again, five hours later [22].

4.2.2. Response

One consultant, from the Alaska Fire Science Consortium, advised on this Observation. The consultant commented that, at the time of posting, there were seven wildfires within 50 miles of the observer's village. The consultant provided EPA resources about the effects of smoke inhalation and how members of the public can protect themselves. The LEO Network coordinators provided information about how to report a wildfire, a link to the website for the Alaska Division of Air Quality, and a link to a wildfire smoke prediction site. The Observation was added to a Project which compiled 27 Observations of wildfire smoke across Alaska.

4.2.3. One Health implications

In this interaction, the observer noted wildfire smoke affecting the air quality surrounding his community. Wildfires can create significant threats to public and animal health and may increase in frequency as the climate changes [23]. Inhalation of wildfire smoke has been associated with increased outpatient visits, emergency visits, and hospital admissions for respiratory problems [24]. Wildfires have been associated with ecological disruption of wildlife and displacement, injury, and illness of livestock and companion animals [25–28]. Through this interaction, the LEO Network connected the observer to reference material regarding protection against wildfire smoke. The LEO coordinators also used this and other Observations to identify a trend of wildfire smoke across the circumpolar north.

4.3. One Health case study 3: permafrost impacts on health infrastructure project

4.3.1. Observations

In May 2012, LEO coordinators created a Project to track the effects of permafrost changes on health and related infrastructure such as food storage facilities, solid waste facilities, and water systems. Five

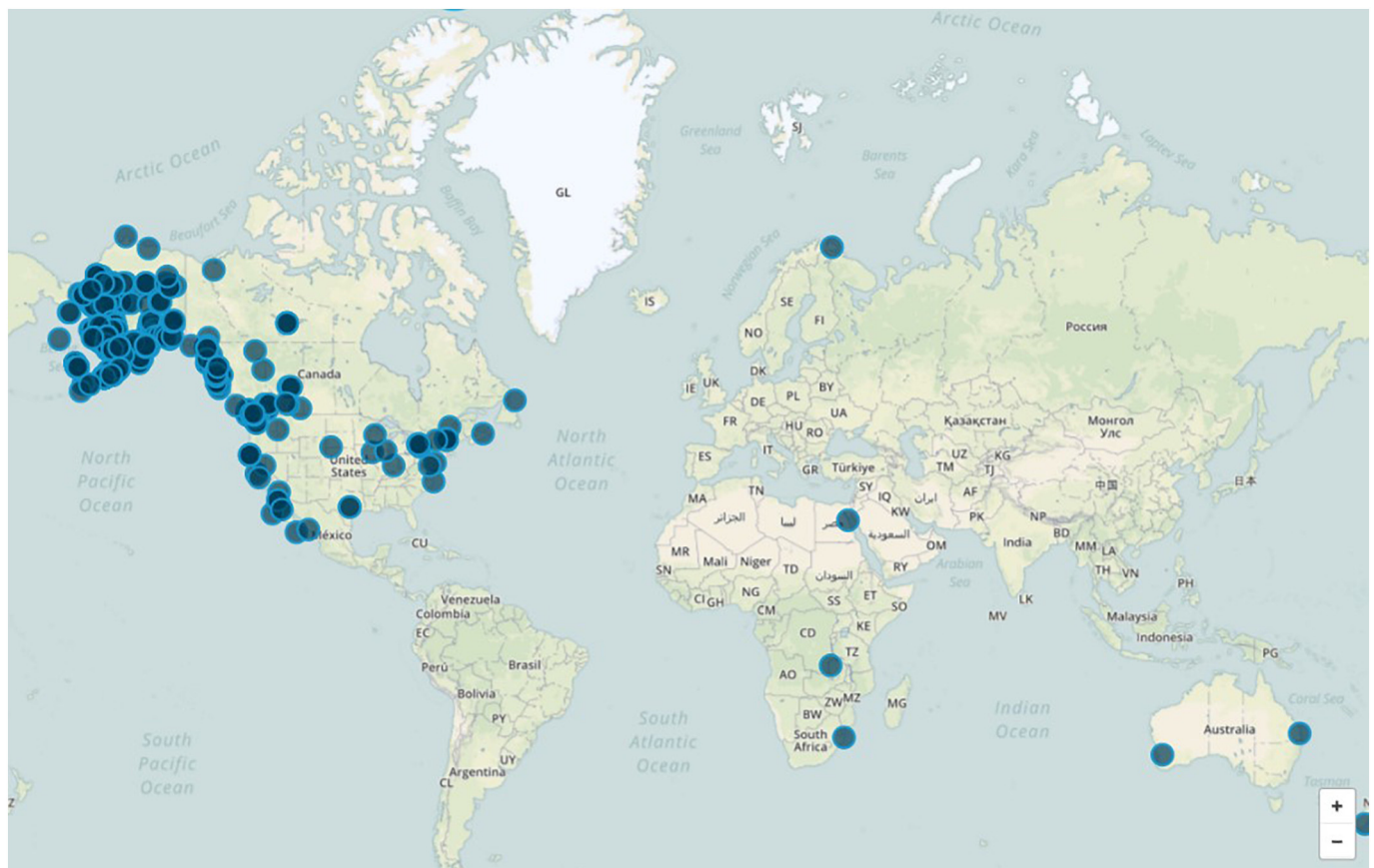


Fig. 2. Local Environmental Observer (LEO) Network Observations location of origin, February 2015–July 2017.

Observations were included as of July 2017, including narrative descriptions of erosion to sewage lagoons, dumps, and water plants, a crack in the tundra, sinking bridges, and warming food cellars [29].

4.3.2. Response

The goal of the Project is to invite observers to participate in discussion, training and method-sharing surrounding changes in permafrost. For each of the Observations in this Project, the LEO coordinators and consultants provided references for environmental and health information to the community observers. Observations can also be used to identify vulnerable communities that may need prevention and adaptation measures.

4.3.3. One Health implications

The breakdown of household or community food storage, water, and waste infrastructure can lead to increased transmission of food-borne, waterborne, and zoonotic infectious diseases, as well as ecologic contamination from human waste. Erosion from thawing permafrost or acute weather events can threaten this infrastructure [30,31]. Permafrost thaw can also have far-reaching effects on wildlife through ecosystem disturbance and potential release of pathogens [32,33]. This Project, initiated by the LEO Network coordinators, provides a repository for narrative Observations of these issues, which can allow for public health or scientific follow-up.

5. Discussion

The LEO Network connects communities to each other and to scientific experts, providing an opportunity for One Health action. For individual observers, the LEO Network can offer advice on One Health issues such as food safety, air quality, and waste disposal. For scientists and public health officials, the system can provide indicators of

potential community health issues, as well as a means of information dissemination. LEO Observations have already been cited in scientific publications [34,35].

Although the LEO Network has multiple functions, it is not a surveillance system for health outcomes. In Alaska, health information is collected through reportable disease surveillance, sentinel surveillance, administrative data, and epidemiologic studies. Through LEO, members may choose to report a health-related outcome that they experienced, but the information is subject to lack of systematization, bias of self-report, diagnostic uncertainty, and confidentiality issues. Despite these limitations, the health information reported through LEO could serve as an indicator of issues requiring follow-up for public health practitioners, similar to unofficial reporting in event-based surveillance [36].

Instead of serving as a health outcome surveillance system, the LEO Network functions as a cataloguing system for potential health-related exposures. The environmental events posted by LEO complement health data that is systematically collected to provide a comprehensive picture of the effects of climate change.

The LEO Network has several areas for growth. First, increases in the number of members and number of Observations will help to represent wider areas and identify patterns in events. Automation of the system could also allow for system wide alerts and notifications based on local trends. Finally, a formal evaluation of the system could yield systematic insight into the impact that it has had on human, animal, and environmental health. An evaluation of this kind could provide evidence for the impact of One Health action that the LEO Network engenders.

Further operationalizing the LEO Network in the context of the One Health and other communities of practice is a priority in coming months and years. This operationalization will allow for further hypothesis-generation and testing using information from the LEO Network. Current LEO Observations can serve as hypothesis-generating

data for public health, veterinary, and environmental scientists. For example, LEO observations were cited in a paper describing the impact of a 2016 heatwave in Alaska [1]. As LEO expands, its Observation trend data will become more robust and could be used for hypothesis generation and hypothesis testing itself.

A One Health approach is critical to address health threats at the human-animal-environment interface and innovative One Health resources are needed. Furthermore, continued integration of environmental health into One Health is necessary to make a holistic public health impact. Although the LEO Network began in an Arctic context, it has the potential to provide insight into environmental changes globally. The network fits into a growing collection of One Health resources that can help address the environmental health needs of communities around the world.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry. Use of trade names is for identification only and does not imply endorsement by the Public Health Service or by the U.S. Department of Health and Human Services.

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