From Map Use Contexts to Map Understanding: Designing Small-Area Cancer Maps through a User-Centered Design Process

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Abstract

Choropleth maps displaying cancer rates have long been used by public health professionals, researchers and policymakers to analyze the spatial distribution of cancer burden for cancer prevention and control. Recent advances in spatial statistics have produced methods to generate reliable small-area cancer estimates. However, such methods have not yet been integrated into existing cancer mapping platforms in the US context due to two major challenges: first, designing interactive map interfaces that effectively communicate and engage diverse users with small-area estimates to support decision-making; second, implementing such a system across states with varying institutional settings, community context and confidentiality requirements.

To address the challenge, we adopt a user-centered design approach to design and implement the Cancer Analytics and Maps for Small Areas (CAMSA) platform for diverse users including public health professionals, researchers and the general public. Specifically, through the needs assessment study, we identified map use context and map understanding goals as design requirements. These requirements were iteratively refined through usability evaluation and implementation capacity studies. We characterized four categories of map use context for CAMSA: the map, the map users, the map use activity and the map use environment. They answer the question: "What conditions shape how the map will be interpreted and used?". Building on these contexts, we identified four levels of map understanding goals that visualization design should support, including map reading, map analysis, map interpretation and map-informed decision making. These goals answer the question: "What should users be able to understand, given those contexts?". Based on these contexts and goals, we

synthesized design outcomes and implications across five design components: data content, visual representation, interaction, textual support and dashboard composition. These components guide how design choices can be configured to support specific map use contexts and map understanding goals.

We operationalized these design implications through an implementation framework consisting of a Data Estimation Layer and a Visualization Layer. The Data Estimation Layer supports the generation and evaluation of small-area cancer estimates. It includes three components: confidential data management, Bayesian modeling with convergence diagnostics, and expert review. The resulting cancer estimates are then communicated through the Visualization Layer, which includes five components: data selection, analysis themes, visualization, dashboard assembling and data exporting. These layers can be integrated or deployed separately to accommodate different data-sharing agreements and institutional constraints. CAMSA has been deployed and adapted across the Iowa, New Mexico, and Kentucky cancer registries, demonstrating how this framework can be adapted to varied institutional and data governance settings.

Our contribution is twofold: first, we identify cartographic representation and interaction strategies that support comprehension and communication of small-area cancer estimates; second, we show how these strategies can be implemented in ways that remain adaptable across state cancer registries with different institutional and data-governance settings. Future work will involve a formal evaluation of how different design strategies support insight generation across user groups.

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