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# Planning the optimal level of local maternity service for small rural communities: A systems study in British Columbia

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ABSTRACT

*Objectives:* To develop and apply a population isolation model to define the appropriate level of maternity service for rural communities in British Columbia, Canada.
*Methods:* Iterative, mathematical model development supported by extensive multi-methods research in 23 rural and isolated communities in British Columbia, Canada, which were selected for representative variance in population demographics and isolation. Main outcome measure was the Rural Birth Index (RBI) score for 42 communities in rural British Columbia.
*Results:* In rural communities with 1 h catchment populations of under 25,000 the RBI score matched the existing level of service in 33 of 42 (79%) communities. Inappropriate service for the rural population was postulated and supported by qualitative data available on 6 of the remaining 9 communities.
*Conclusions:* The RBI is a potentially pragmatic tool in British Columbia to help policy makers define the appropriate level of maternity service for a given rural population. The conceptual structure of the model has broad applicability to health service planning problems in other jurisdictions.



## 1. Introduction

Rural maternity health services across Canada are currently in flux, as evidenced by the closure of small and isolated services and the migration of women from their home communities to give birth [1–5]. Health planners are tasked with the challenge of making resource allocation decisions that are economically viable and meet the maternity health care needs of rural populations within a context of competing priorities [6,7]. Additional pressures arise out of the nature of health care delivery systems themselves, which are characterized by their dynamic complexity and lack of stasis. This is further complicated by the lack of a systematic approach to rural health services planning and the absence of a robust evidence base to inform such planning [7–10]. A review of policy documents from British Columbia covering the past decade provides little evidence of systematic planning for maternity care services in general and for rural maternity care services in particular. This lack of direct policy attention to rural maternity care means much of the decision making with respect to services has occurred in an ad hoc manner in response to a local or regional sense of crisis [9]. This paper presents a case study of systems modeling related to the assessment of the appropriate level of maternity services for communities in rural British Columbia, Canada with populations of less than 25,000 and addresses the question: *What level of service should be provided to the community*

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*based on population need in order to optimize service sustainability?*

## 2. Background

British Columbia is Canada's western-most province with a population of 4 million, of which 25% lives outside of major urban centres. The province's geography is characterized by mountainous valleys and coastal communities, which present significant transportation challenges, especially in inclement weather. In the past 10 years, many small rural maternity services have closed in British Columbia and across Canada [2,5,11], with 20 closures in British Columbia alone since 2000 [8,12]. These closures have occurred for a variety of reasons including the centralization of services within a health authority [4,13,14], concerns about the safety of a small unit in the face of bad outcomes [5], and difficulties in recruiting providers to staff small rural maternity units [4,15–18]. These closures have taken place against a backdrop of policy recommendations that speak to the importance of supporting women to be able to give birth closer to home [19,20], and a relatively thin and inconclusive body of literature about the safety of small rural maternity services with and without cesarean section capacity [21–27].

A review of the literature on rural health services planning demonstrates a number of approaches to the application of predictive modeling to service delivery challenges [28–30]. However, most of these models attempt to include determining factors (geography and population demographics) with a multiplicity of feasibility characteristics (e.g. analysis of existing facilities and human resources issues) without prioritizing between the two types of characteristics—population need and feasibility. For example, the British Columbia Standards of Accessibility identify population characteristics and distance/geography alongside professional competence and critical mass in their determination of minimal requirements of accessibility to services [7]. Likewise, *The Rural Birthing Services Framework* from Australia identifies the importance of determining population need based on demographics and isolation as a means of elucidating the level of service desired through a consultative development process [31]. The framework does not, however, distinguish between core population characteristics and associated feasibility characteristics such as the complement and training of the clinical staff and support services. While *The Rural Birthing Services* framework is conceptually useful, the criteria of how to apply it as a predictive tool are not explicit. A similar critique may be levelled against Battye and McTaggart's development of a model for sustainable delivery of outreach allied health services to remote north-west Queensland, Australia [29].

Other research has investigated the relationship between community characteristics and the presence of maternity services in small rural hospitals. For example, Lambrew and Ricketts (1993) applied logistic regression to understand the association between demographics, geographic location, and socioeconomic status and the ability of rural hospitals to sustain local obstetrical services. The authors concluded that "Community conditions, such as levels of unemployment, racial composition or proximity to other hospitals or metropolitan areas, may be primary rather than secondary determinants of the viability of local obstetrical care systems" [32, p. 284]. These findings suggest the importance of disaggregating the characteristics of the population, such as population birth numbers, social vulnerability, and isolation, from other social characteristics when planning services.

## 3. Methods

This model development set out to answer the question, *Can we predict the appropriate level of sustainable maternity service for a rural community based on population need?* We used John von Neumann's operationalization of the term "model" to refer to "a mathematical construct which, with the addition of certain verbal interpretation, describes observed phenomenon. The justification of such a mathematical construct is solely and precisely that it is expected to work" [cited in 33, p. 273]. More recent work informing our approach comes from the field of operational research and identifies stages of knowledge acquisition and model abstraction and highlights the advantages of keeping a model simple [35–37]. The approach undertaken was informed by the recognition that systems are dynamic and multi-faceted and must be studied using multiple methods and an iterative process to ensure the responsiveness of the model [34]. Furthermore, we privileged a transdisciplinary approach to model development that incorporated in-depth understanding of the clinical and social realities of rural maternity care. The former was informed by one of the authors (S.G.), who worked as a rural family physician providing maternity care in an isolated community for 11 years and the latter by a sociologist (J.K.), who has studied the social aspects of childbirth for the past 10 years. The research support team included individuals with backgrounds in anthropology, geography, health policy and administration, psychology, and epidemiology. The model development was underscored by a recognition that in the special circumstance of rural and isolated communities, three dominant characteristics are predictive of rural service stability: *population* birth numbers, the *social vulnerability* of the local population, and the degree of *isolation* of the community. Identification of the importance of these characteristics arose out of the authors' comprehensive understanding of rural maternity care service delivery issues based on prolonged research engagement with a range of rural study communities and key informants.

Prolonged engagement occurred directly through nine studies which used both quantitative and qualitative methods. The first three studies have been completed and a number of publications have resulted [4,22,38]. The remaining studies are currently in progress and include an investigation of: newborn outcomes by rural maternity service level, 1994–1999; parturient women and families' experience of birth in and away from their home communities [39,40]; care providers and administrators' experiences of providing maternity care [41,42]; the effects of small hospital maternity service closures on referral hospitals [43]; the experience of general practitioner surgeons providing surgical obstetrics to rural communities; and the application of a logic model approach to the planning of sustainable rural maternity services. Cumulatively, we have visited 23 communities and interviewed 121 women, 217 providers, and 49 administrators/key informants. Interviews were transcribed and analyzed. We carried out four community forums and undertook 540 chart reviews and analyzed provincial data from the British Columbia Reproductive Care Program (BCRCP) to determine maternal–newborn outcomes in referral hospitals. Data for the newborn outcomes pilot study was provided by the British Columbia Linked Database. Conclusions regarding the sustainability of individual services were based on the duration of stability of a given service level within a given community based on BCRCP data and interviews with a range of key informants in the communities under study. Ethics approval was granted for the studies informing this project through the Behavioural Research Ethics Board of the University of British Columbia and from the ethics boards of the hospitals studied and their respective health authorities.

### 3.1. *The formula*

Our extensive immersion in the phenomena of rural maternity services and our cumulative, programmatic data gathering process led to insights into the hypothetical weighting of the factors most significant in influencing the sustainability of services: population birth numbers, social vulnerability, and geographic isolation. A trial formula was developed and applied to the derivation sample of rural communities with existing or recently closed local maternity services and catchment populations of less than 25,000 ($n = 42$) based on BCRCP data. The formula was iteratively tested and validated through sensitivity analyses [44]. By adjusting the strength and significance of inputs, we refined the mathematical model to establish the best fit with the cumulative quantitative and qualitative understandings that we had accrued with respect to the sustainability of individual services.

The formula is

$$\text{RBI} = (\text{PBS} \times \text{APV}) + \text{IF}$$

where RBI is the Rural Birth Index; PBS is the population birth score; APV is an adjustment for population vulnerability, and IF is the isolation factor (Fig. 1).

The steps in developing the RBI score are as follows:

(1) *Defining a population-based 1 h catchment area of a hospital by surface travel time:* To define the population serviced by a given hospital, we created rural population-based catchments based on previous research for all 42 British Columbia communities in the study (see Fig. 2) [45].

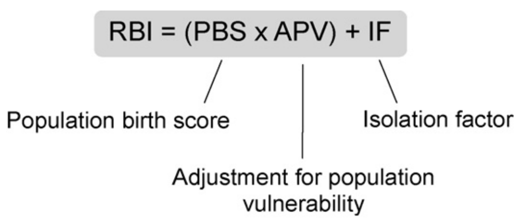


**Fig. 1.** Rural Birth Index (RBI).

**Table 1**
Isolation factor scale.

| Surface travel time | Isolation factor (IF) |
|---|---|
| <30 min | −3 |
| 31–45 min | −2 |
| 45–60 min | −1 |
| 60–90 min | 1 |
| 90–120 min | 2 |
| 2–4 h | 3 |
| >4 h | 4 |

(2) *Defining the population birth score (PBS):* We calculated the average number of births in the 1 h catchment area of a hospital over five years, and divided this number by 10 to reduce the value of the variable to a more concise number. Had we left the value as a raw number of births, the results of our formula would have run from 0 to 250 rather than from 0 to 25. We weighted the other components of the formula to reflect the values in the population birth score, and applied this uniformly across all communities.

(3) *Calculating the adjustment for population vulnerability (APV):* Each community catchment was assigned a score of social vulnerability derived from the previously validated British Columbia Statistics Socio-Economic Indices, which measure the social vulnerability of a Local Health Area population over a range of −1 (socially advantaged) to +1 (socially disadvantaged) based on the following factors: economic hardship, crime, health problems, education concerns, children at risk, and youth at risk [46]. We initially applied this variable to each community's birth score by adjusting the score by a factor of 0.8–1.2 depending on the BC Stats score (where 0.8 correlated with a −1 score and 1.2 correlated with a + 1 score). Further sensitivity analysis determined best fit with the existing qualitative data for the 23 communities in our program of research over a 0.8–1.4 range. Asymmetry in the adjustments reflects an awareness that, in British Columbia, social vulnerability has a more significant influence on access to health services, and, ultimately, health outcomes than social advantage [39,40].

(4) *Measuring proximity to nearest cesarean section service and attributing an isolation factor (IF):* Surface travel time to the service was categorically weighted as illustrated in Table 1. Even if a community currently had cesarean section services, in order to accurately assess a given community's needs, the isolation factor was defined based on the distance to the next closest service with cesarean section capability. Further, for populations that were less than 1 h from services, we recognized that proximity can detract from the sustainability of a maternity service and consequently weighted the factor accordingly (see Table 1). A distance of 1 h travel time is recognized as an important threshold for appropriate access to emergency services, including intrapartum care [7]. In our model, travel times of greater than 1 h were weighted in a stepwise fashion and reflected our qualitative findings which emphasized the important influence of isolation on sustainability of very small maternity services. We purposefully dealt with isolation as a summative component in the formula as our qualitative research suggested that it is only in small birthing populations (30–90 births per year) that isolation is a critical factor.

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**Fig. 2.** 1 h surface travel time catchments and maternity service levels of rural BC hospitals, 2007.

This formula results in a "Rural Birthing Index" (RBI) score for each rural British Columbia community in our sample. Each score correlates to a recommended service level (see Table 2). We parameterized the model against existing stable rural maternity services in British Columbia (exhibiting these organizational properties) to calibrate the RBI scores to existing levels of service. We also scored communities that have changed service levels since 2000. We defined rural maternity service levels according to degree of local cesarean section capability as, in British Columbia, local surgical capability is the most important determinant of the proportion of women who will be able to deliver locally [47,48]. Furthermore it is important to recognize that cesarean section capacity in a community directly depends on the presence of a broad range of ancillary obstetric services, such as pediatric, anaesthetic, and nursing support, an operating room, and neonatal resuscitation services.

**Table 2**
Application of the RBI Score to community service levels.

| Rural birth index (RBI) score | Maternity service level |
|---|---|
| 0–7.0 | A—No local intrapartum services |
| 7.0–9.0 | B—Local intrapartum services without operative delivery |
| 9.0–14 | C—Local GP surgical services |
| 14–27 | D—Mixed model of specialists and GP surgeons |
| >27 | E—Specialist only models |

## 4. Results

The Rural Birth Index scores accurately reflect the existing level of maternity service in 33 of 42 British Columbia communities (79%) (see Table 3). Of the remaining 9 communities, we postulate that most are inappropriately serviced based on qualitative data gathered in 6 of the 7 communities that we have visited to date, while the remaining two communities have not been included in qualitative data collection. Based on these results, the RBI tool has identified the appropriate level of rural maternity service for 38 of 42 communities studied. For communities with an inappropriate or unsustainable level of service the formula flags them as under- or overserved.

The RBI tool identifies British Columbia communities for which there is a difference between the optimal service level predicted and the existing service. Table 3 categorizes the 42 communities in our study by existing service level, and identifies the communities that do not currently pro-

**Table 3**
RBI scores applied to British Columbia rural maternity services.

| | Hospital catchment population | PBS | APV | Nearest C-section service | Travel time | Isolation factor (IF) | Rural birth index (RBI) | Predicted level of service |
|---|---|---|---|---|---|---|---|---|
| Communities where intrapartum services have closed since 1996 (Existing service A)[a] | | | | | | | | |
| Kimberley | 9,049 | 5.5 | 0.88 | Cranbrook | 32 m | −2 | 2.8 | A |
| Summerland | 11,891 | 7.1 | 0.84 | Penticton | 20 m | −3 | 3.0 | A |
| Sparwood | 6,643 | 5.0 | 1.35 | Fernie | 30 m | −3 | 3.7 | A |
| Enderby | 7,724 | 5.7 | 1.08 | Vernon | 43 m | −2 | 4.1 | A |
| Ashcroft | 2,900 | 1.8 | 1.20 | Kamloops | 1 h 38m | 2 | 4.2 | A |
| Princeton | 4,899 | 2.4 | 1.24 | Penticton | 1 h 57 m | 2 | 5.0 | A |
| Alert Bay | 1,200 | 1.4 | 1.14 | Comox | 5 h 44m | 4 | 5.6 | A |
| Lytton | 5,000 | 3.2 | 1.20 | Kamloops | 1 h 38 m | 2 | 5.8 | A |
| Nakusp | 5,194 | 3.2 | 1.00 | Nelson | 2 h 32 m | 3 | 6.2 | A |
| Castlegar | 13,614 | 9.0 | 0.94 | Trail | 33 m | −2 | 6.5 | A |
| Clearwater | 5,340 | 4.6 | 1.00 | Kamloops | 1 h 32 m | 2 | 6.6 | A |
| Bella Bella | 1,200 | 2.1 | 1.27 | Vancouver | >4 h | 4 | 6.7 | A |
| Hope | 8,891 | 6.9 | 1.32 | Chilliwack | 45 m | −2 | **7.1**[c] | **B** |
| Masset | 2,700 | 3.0 | 1.12 | Prince Rupert | >4 h | 4 | **7.4** | **B** |
| Port Hardy | 5,000 | 5.7 | 1.14 | Campbell River | 2 h 47m | 3 | **9.5** | **C** |
| Oliver | 19,521 | 12.1 | 0.98 | Penticton | 45 m | −2 | **9.9** | **C** |
| Merritt | 11,749 | 10.5 | 1.35 | Kamloops | 54 m | −1 | **13.2** | **C** |
| Communities with no local surgical service (Existing service B) | | | | | | | | |
| Queen Charlotte City | 2,700 | 3.0 | 1.12 | Prince Rupert | >4 h | 4 | 7.4 | B |
| Port McNeill | 3,500 | 4.0 | 1.14 | Campbell River | 2 h 23 m | 3 | 7.6 | B |
| Invermere | 10,559 | 6.1 | 0.93 | Cranbrook | 1 h 41 m | 2 | 7.7 | B |
| Salt Spring Island | 10,000 | 5.7 | 0.91 | Victoria | 2 h 51 m | 3 | 8.2 | B |
| Tofino | 4,873 | 4.3 | 1.3 | Port Alberni | 2 h 06 m | 3 | 8.4 | B |
| Fort St. James | 7,000 | 8.9 | 1.20 | Vanderhoof | 45 m | −2 | 8.7 | B |
| Hazelton | 5,756 | 7.3 | 1.34 | Smithers | 1 h 11 m | 1 | **10.8** | **C** |
| Communities with surgical services provided by General Practitioner Surgeons (Existing service C) | | | | | | | | |
| Revelstoke[b] | 8,593 | 7.9 | 0.90 | Salmon Arm | 1 h 23 m | 1 | **8.1** | **B** |
| Golden[b] | 7,914 | 6.4 | 0.93 | Cranbrook | 3 h 04 m | 3 | 9.0 | C |
| Grand Forks | 10,992 | 7.2 | 0.99 | Trail | 1 h 44 m | 2 | 9.1 | C |
| Lillooet | 4,800 | 5.4 | 1.21 | Kamloops | 2 h 53 m | 3 | 9.6 | C |
| Bella Coola | 3,394 | 4.6 | 1.27 | Williams Lake | >4 h | 4 | 9.9 | C |
| Kitimat | 11,721 | 10.4 | 0.97 | Terrace | 1 h 09 m | 1 | 11.1 | C |
| Vanderhoof | 8,000 | 10.1 | 1.20 | Fort St. James | 53 m | −1 | 11.2 | C |
| 100 Mile House | 14,945 | 10.2 | 1.05 | Williams Lake | 1 h 23 m | 1 | 11.7 | C |
| Burns Lake | 7,889 | 8.9 | 1.16 | Vanderhoof | 1 h 32 m | 2 | 12.3 | C |
| Creston | 12,961 | 12.0 | 0.99 | Cranbrook | 1 h 34 m | 2 | 13.8 | C |
| Fort Nelson | 6,742 | 9.3 | 1.06 | Fort St. John | >4 h | 4 | 13.9 | C |
| Smithers | 18,085 | 22.4 | 0.97 | Hazelton | 1 h 11 m | 1 | **22.8** | **D** |
| Communities with surgical services provided by General Practitioner Surgeons and Specialists (Existing service D) | | | | | | | | |
| Fernie | 15,894 | 12.0 | 0.92 | Cranbrook | 1 h 26 m | 1 | **12.0** | **C** |
| Trail | 20,325 | 13.3 | 0.98 | Nelson | 1 h 07 m | 1 | 14.1 | D |
| Powell River | 20,720 | 14.8 | 1.09 | Comox | 1 h 38 m | 2 | 18.2 | D |
| Nelson | 24,930 | 21.0 | 0.96 | Trail | 1 h 07 m | 1 | 21.1 | D |
| Prince Rupert | 16,625 | 19.9 | 1.22 | Terrace | 1 h 39 m | 2 | 26.3 | D |
| Communities with surgical services provided by Specialists without General Practitioner Surgeons (Existing Service E) | | | | | | | | |
| Terrace | 22,396 | 26.2 | 1.20 | Kitimat | 0 h 55 m | −1 | 30.3 | E |

*Notes*: (a) These are "closed maternity services" as defined by the British Columbia Reproductive Care Program [8]. (b) Isolation is underestimated by travel time alone due to frequent seasonal mountain pass road closures. (c) Bold values denote RBI scores of communities for which there is a difference between the predicted and existing service level.

vide their predicted level of service, the majority of which have no local maternity care (Level A).

For communities whose predicted level of service does not match the existing level of care, our program of qualitative research indicates that consequences include service instability and a heightened sensitivity to factors influencing unsustainable service. For example, the community of Masset on the Queen Charlotte Islands which scores 7.4 on the RBI scale (scores of 7.0–9.0 correlate with service Level B, local maternity care without cesarean section) has vacillated between providing and not providing local services during the past 10 years. In this community, the safety of providing local services without access to cesarean section is weighed against the reality of women refusing to travel away to access services and birthing outside the system. Each time the local service closes, community pressure mounts on the hospital and local providers to reopen services. This culminated in 2008 in an innovative local community initiative leading to the completion of a new hospital facility that will provide enhanced local birthing services.

The RBI model indicates that the study community with the greatest discrepancy between existing and predicted level of maternity service is Merritt, a community in the

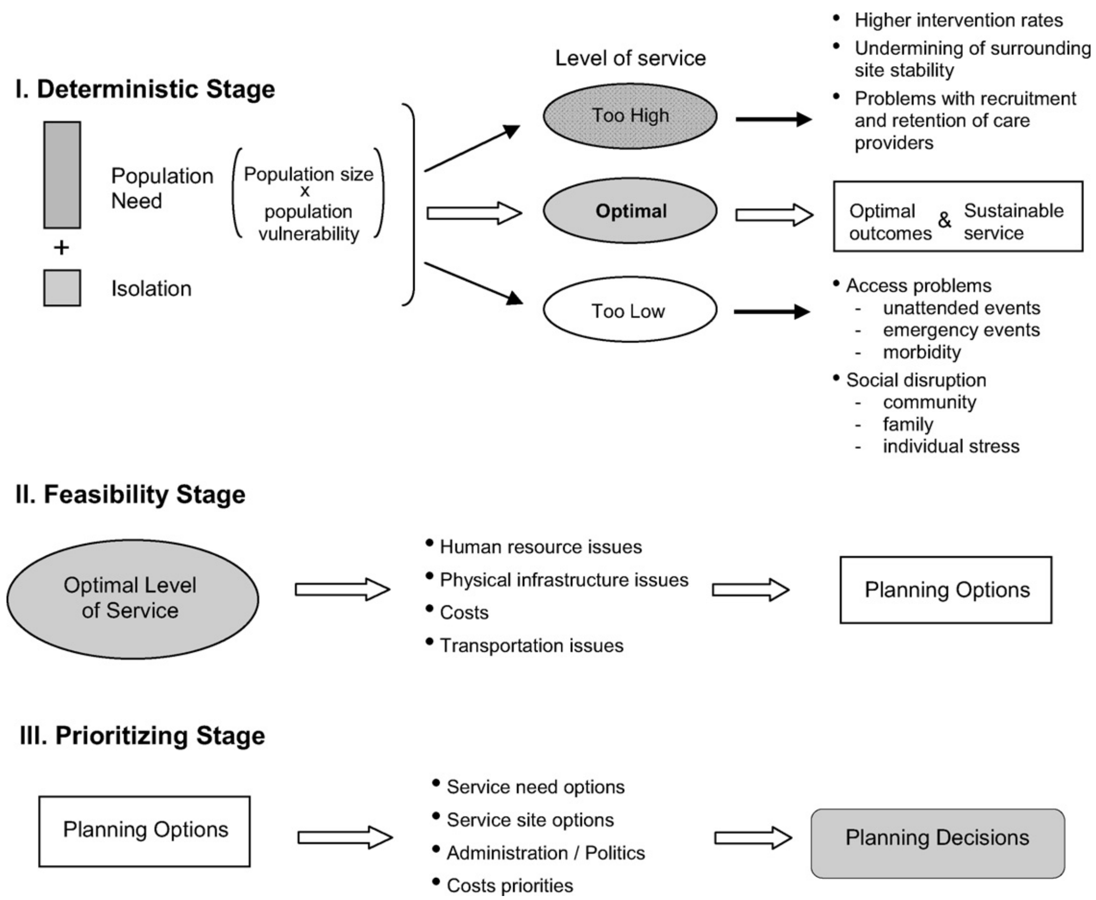


**Fig. 3.** A theoretical framework of planning and evaluating rural health services.

interior of British Columbia. The community lost Level B maternity services in 2001 and has not provided local intrapartum care since. Merritt has on average 105 annual births (PBS = 10.5), a highly vulnerable population of women of low socioeconomic status (APV = 1.35), and is 54 min from the nearest cesarean section service across a high mountain pass highway (IF = −1). Consequently, Merritt has an RBI score of 13.2 and not only should have local maternity services, but also local cesarean section when compared to communities in British Columbia with similar population characteristics.

When a community's RBI score is close to a service transition point (scores near 7, 9, and 14), the potential for influencing factors to dramatically shift levels of service is much higher than when the score is closer to the midpoint of the range for a given service level (see Table 2). In such instances, local system and resource challenges can outweigh population need. For instance, the small, isolated community of Bella Bella on British Columbia's central coast (RBI score 6.7), lost local maternity services in 2001 due to a confluence of factors including difficulty recruiting and retaining a general practitioner with enhanced skills (GP Surgeon) to provide local access to cesarean section, and the reluctance of physicians to offer maternity care without the availability of such services [49]. The community has expressed a determination to have local birth return to Bella Bella, but care provider recruitment and retention challenges continue to undermine the reestablishment of sustainable local services.

## 5. Discussion

This is a systems study of modeling a rural health care service based on community population size, social vulnerability, and degree of isolation. The model has been parameterized and tested for rural maternity health services within British Columbia. The Rural Birth Index formula that we have derived and modified based on sensitivity analysis and fit with our qualitative understanding of rural community maternity service stability and appropriateness works well for the majority of the rural services in the province. This demonstrates the potential utility of privileging population need and isolation as defining characteristics of sustainable services. Most importantly it dramatically highlights communities that have a service level out of sync with the majority of communities in British Columbia (e.g. Merritt; see Table 3) and provides policy makers and programmers with objective data to plan health services to meet population need.

The consequences of providing an inappropriate level of service for a rural community include negative medical and psychosocial outcomes for patients as well as care providers [40–42]. For example, within the context of rural birthing services in British Columbia, our exploratory research suggests that if no local intrapartum services exist in a community where local services are appropriate according to the RBI score, clinically significant numbers of women will choose sub-optimal alternatives to traveling to access maternity care at a referral hospital. These alternatives include the "10 cm strategy" (arriving at the local hospital fully dilated to preclude transfer out of the community), and even unassisted home birth [38,39]. These options are associated with significant morbidity and occur more frequently in communities that are underserved and where barriers to accessing maternity services exist [38–40]. Where these sub-optimal solutions are being chosen by birthing women, it indicates a need for local service review on the part of administrators and planners. Further, the frequency of such solutions to diminished access to care will increase as the size of the birthing population increases and as the social resources of the women decrease. The RBI score can be used in such circumstances to define the optimal level of service for the community. Where the appropriate level of service is no local maternity care, strategies for efficient management of emergency deliveries and transfer can be developed, such as emergency delivery skills upgrading for local medical and ambulance staff.

The RBI model was designed to be applied to rural communities with populations under 25,000 and is focused on access to maternity services. For larger maternity care delivery services, such as those found in urban centres, the system is more complex and isolation is not a factor as local surgical services are assumed. However, this formulaic approach and the conceptual characteristics underpinning the RBI may be adaptable to strategizing delivery models for other health services in rural and isolated communities. For instance, services such as cancer, palliative, or emergency care can be planned using an appropriate framework and adaptation of the RBI model that focuses on population need, isolation, and vulnerability. The model may be further applied to plan services to meet the needs of communities based on population projections [50].

Adaptation of the formula for other rural jurisdictions and health services requires parameterization of the relationships between the variables to reflect the characteristics of a given environment or service. For instance, the population birth score variable can be adapted to a population case volume score to measure the annual number of patients in a community seeking a particular health service. The adjustment for population vulnerability (APV) requires minor adaptation depending on the vulnerability characteristics of populations within different health systems and social contexts, and depends on the availability of population-based social vulnerability data, such as socioeconomic status scores. The results of our APV sensitivity analysis are relevant to the context of a Canadian publicly funded system of medicine and the mitigating influences that universal access to health care provides. The effect of social vulnerability in other jurisdictions would need to be recalibrated based on a location-specific sensitivity analysis. For example, adaptation of the formula for jurisdictions without publicly funded health care will have to account for lack of universal coverage and the consequent challenges to access for the uninsured. In such jurisdictions, we would predict that the formula will require a greater range of adjustment for population vulnerability depending on the proportion of a given rural population that is without medical insurance. We believe that the isolation factor is transferable to other rural jurisdictions and services. In addition, the output of the adapted formula will have to correspond with a model of optimal service levels that reflects the current health care system of a given jurisdiction: existing levels of service, types of care providers, and service level transition points (see Table 2).

This case study provides rural health services planners in British Columbia with a recommended appropriate and sustainable level of service for a given small rural community compared to other sustainable rural services in the province. This potentially provides an objective foundation for the planning process and a rationale for health service decisions. This is stage one of what we envision as a three-stage planning process (see Fig. 3). Stage one, the *deterministic* stage, is the objective measurement of the characteristics of population need related to the service under study: population size, vulnerability, and isolation (i.e. determining the RBI). Stage two, the *feasibility* stage, addresses the question: *What are the pragmatic issues that need to be considered in locating a particular health service in a given rural community?* These issues may involve a review of existing facilities, availability of health human resources, history of the service in the community, and consideration of transport and economic issues. A potential approach to this stage can be a decision analysis framework. Stage three, the *prioritizing* stage, is addressed at the senior planning table for the health administrative agency and involves establishing the importance of the given service within a context of competing service issues. The methodology for stages two and three will be the subject of future research articles. In addition, population-based service catchments (see Fig. 2) can provide health planners with the data to systematically monitor a broad range of health outcome and utilization indicators and form the basis for a comprehensive quality improvement framework [51].

## 6. Conclusion

The development and application of the Rural Birth Index in the province of British Columbia, Canada, demonstrates the potential utility of systems thinking in creating a pragmatic tool to help policy makers define the appropriate level of maternity service for a given rural community based on population need and degree of isolation. Program planning can be facilitated by disaggregating the process into three stages: determining need, assessing feasibility, and prioritizing service demands (Fig. 3). The efficacy of this modeling exercise was catalyzed by a multi-methods transdisciplinary approach and prolonged immersion in the phenomenon. Further study is needed to explicate the application of the conceptual model to other rural jurisdictions and health services. Specifically, further study may address the adaptation of the RBI for rural maternity care service in other jurisdictions, explore the formulaic

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fit with care provider models in other health care systems, and investigate the conceptual approach of planning other health services based on population need and isolation.

## Conflict of interest

The authors have no potential conflicts of interest.

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