

## PROCESS AND SYSTEMS A Canadian Rural Living Lab Hospital: Implementing solutions for improving rural emergency care

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### ABSTRACT

#### Introduction

More than 6 million Canadians live in rural areas (approximately 20% of the population) and emergency services are a critical safety net for them.

#### Objectives

We want to create, in Baie-Saint-Paul (rural emergency department, Québec, Canada), an experimental milieu where all stakeholders develop, implement and evaluate solutions to address the problems that beset their environment.

#### Method

The Living Lab will rely on the quadruple aim approach to improve health system performance and will use a multimethod approach based on the philosophy of open and user-driven innovation. Three pilot projects will be implemented (quality of work life programme, computed tomography implementation study and telemedicine in ambulances). Other possible solutions will be evaluated and prioritised (*in situ* simulation, care protocol, telemedicine, point-of-care ultrasound, helicopters and drones).

#### Conclusion

We are confident that this Living Lab will contribute to saving lives, will improve the quality of work life for rural healthcare professionals, and will inspire similar innovation internationally.

**KEYWORDS:** Emergency medicine, rural, Canada, Living Lab

*If there is two-tiered medicine in Canada, it's not rich and poor, it's urban versus rural.*

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#### Preface: Destiny and a promise to improve rural emergency care

In the early 2000s, governments across Canada made massive healthcare cuts in rural areas, closing hospitals and reducing support services.<sup>2,3</sup> In the rural hospital where I started my medical career in Nelson, British Columbia, the general surgery programme, intensive care and inpatient mental health unit closed; radiography as well as laboratory services were cut and there was no computed tomography (CT) scanner. In the context of geographic isolation and limited capacity for medical evacuation (med-evac), community members and healthcare professionals staunchly advocated to save their services.<sup>4</sup> Trained like most physicians in an urban academic setting, I was not prepared. I still have chills when I think of the last patient I treated in Nelson:

*At 4am, an elderly patient presented with abdominal pain. I performed bedside ultrasonography in search of an explanation for her pain. She had a large (6.5 cm) abdominal aortic aneurysm and urgently needed vascular surgery – only the service was 400 km away. While I explained the situation to her, she interrupted, 'Doctor, by the way, I want to thank you for standing up for us. I have read you and your colleagues' articles in the newspapers about your opposition to the service cuts. We used to have a fabulous hospital here before all the cuts. I understand some of you may leave, and I don't blame you.' Surprised and touched, I forged ahead with my explanation of her medical condition and arranged an urgent transfer. At the end of my shift (around 7am), she told me unequivocally, 'Doctor, if I don't see you again, promise me one thing: please continue the fight.' Unfortunately, her transfer did not go well. The plane was delayed several times, and she eventually was transferred by road ambulance – a 5-hour transport. She arrived unacceptably late, at about 6pm. She died before surgery.<sup>4</sup>*

Since 2010, our entire research programme has been inspired by this frontline clinical experience as a rural doctor. As we enter the next stage of our research, we recall that the journey started in one small rural hospital with immediate and desperate needs. We have decided to come full circle and attempt to bring about change in one small rural hospital. We want to develop the most scalable model for optimal rural care – a model that can then inspire others and effect change locally and globally.

## Introduction

More than 6 million Canadians live in rural areas (approximately 20% of the population) and emergency services are a critical safety net for these communities.<sup>5,6</sup> Rural emergency departments (EDs) are of high importance for Canadians (4 million annual visits to over 300 rural EDs) and yet are frequently poorly resourced – most have no access to on-site CT or surgical services.<sup>7–9</sup> The rural population is older and in poorer health than in urban settings and are at higher risk of death.<sup>7–9</sup> Our studies have shown that Canadian patients treated in rural hospitals are 20% more likely to die from a stroke than patients treated in urban hospitals and that rural Quebec trauma patients had pre-hospital and ED mortality rates 3.4 times higher than their urban counterparts.<sup>10,11</sup>

We have also previously undertaken a number of research projects aimed at integrating scientific knowledge about rural EDs with the experiential knowledge of various stakeholders.<sup>12–14</sup> Among them, the Rural Emergency Care 360 project aimed to engage rural community members, healthcare providers, managers and policymakers in identifying needs, and imagining and taking ownership of initiatives likely to improve care and services.

This project gave rise to the idea of establishing a ‘Living Lab’: an experimental milieu where patients, community representatives, decision makers, researchers, healthcare professionals and other stakeholders collaborate to address the persistent problems that beset their own rural environment.<sup>15</sup>

## Goal and objectives

The goal is to design and implement a rural Living Lab in the ED at Baie-Saint-Paul hospital (Québec, Canada) where transformative, user-designed, point-of-care solutions will be co-developed, implemented and evaluated in a sustainable and scalable way.

We will proceed with pilot experimentation projects to bring together stakeholders, build confidence and trust, foster a culture of co-creation and demonstrate the first results to facilitate funding. Three projects emerged, on the basis of the most urgent needs as identified by local stakeholders, and will be implemented in the months to come: a work environment improvement project (Project 1a), an evaluation of the implementation of CT (Project 1b) and a telemedicine project (Project 1c).

We will then prioritise further user-designed solutions and, if selected, implement additional solutions in the Living Lab.

## A Living Lab with a quadruple aim approach to improve health system performance

### The idea: Living Labs

The Living Lab concept emerged from the Massachusetts Institute of Technology Media Lab at the end of 1990 and was further developed by the European Network of Living Labs (ENoLL) founded in 2006. It is a multimethod approach based on the philosophy of ‘open’ and ‘user-driven’ innovation, where experimentation takes place in real-life contexts and seeks to address real-world problems.<sup>15</sup> Living Labs were originally conceived to meet innovation challenges faced by information and communication technology. Now, examples of Living Labs can be found in various fields including urbanism, education, technology development, and healthcare.<sup>15–20</sup> The Living Lab process is based on a four-step iterative process involving an interdisciplinary, multi-stakeholder team.<sup>15</sup>

- > *Co-creation*: supports the mindset of using multiple points of view to work through the challenges, constraints and opportunities that arise while creating new scenarios and concepts.
- > *Exploration*: engages all stakeholders in the materialisation of the scenarios in a safe space where all the stakeholders can think of creative ways to solve the problems.
- > *Experimentation*: implements scenarios with large groups of users in order to collect data that will be analysed during evaluation.
- > *Evaluation*: assesses new ideas and innovative concepts in real-life situations through various dimensions (social, economic, cultural, patient experience, quality of care etc) and makes observations on the potential and adoption through a confrontation with users’ value models.

In establishing a patient/community-centred Living Lab where evidence-based innovations to improve rural emergency care can be rapidly deployed, tested and spread, our programme seeks to optimise health system performance in the pursuit of the quadruple aim.<sup>21</sup> Hence, the Living Lab aims to:

- > *improve the health and safety of the rural population*. By creating a space where innovations in rural emergency medicine can be implemented and tested, the Living Labs will contribute to evidence-based healthcare and, ultimately, to improving the health of the vulnerable rural population.
- > *improve the quality and experience of rural emergency care for patients and their families*. Our research projects, past and ongoing, invite patients and other rural emergency stakeholders to engage in addressing rural healthcare problems and providing solutions based on their needs and experiences. Dubé *et al* speak of the Living Lab approach as being ‘user-driven’.<sup>16</sup> This programme thus includes the implementation of user-prioritised solutions. Patients and communities are already privileged partners of the Living Lab project and its structure will reflect this. Our programme will also provide patients and other stakeholders with a better equipped ED, improving access to care locally (eg providing CT and telemedicine remote support, point-of-care ultrasound (POCUS), state-of-the-art simulation training etc).
- > *improve quality of work life and retention rates of rural emergency care providers*. Many of the key problems identified in rural emergencies are related to human resources (recruitment, retention and qualifications).<sup>22,23</sup> Our programme has several projects that aim to create and sustain a culture of creativity, innovation and workforce well-being, including an evidence-based wellness programme. Better equipment will also attract and retain medical specialists, and the engagement of local stakeholders in taking responsibility and ownership for solutions will reduce social and professional isolation. The initiative will attract healthcare professionals and researchers to work and establish themselves in rural regions and will reduce work absenteeism, burnout and medical errors.
- > *optimise per capita cost of healthcare*. Our programme includes several projects (including establishing the Living Lab itself) that are based on private–public partnerships and all projects will seek value-based care. The Living Lab will help us study which solutions are cost-effective and more desirable for stakeholders. The Living Lab project will integrate the core

principles of 'learning healthcare systems' and 'healthcare-based value'.<sup>24,25</sup> It will lead to long-lasting collaborations between health economists, health services researchers and healthcare professionals for the design, improvement and establishment of performance measures, and help prepare for the future of healthcare.

## Designing and implementing the rural Living Lab Hospital in Baie-Saint-Paul

### The real-life context

Baie-Saint-Paul Hospital is a state-of-the-art facility built in 2018 to be resilient to the region's seismic potential. The ED receives an average of 13,500 visits per year. The hospital has 30 acute care beds, seven mental health beds, one ED, an intermediate critical care unit and 24/7 access to basic laboratory and radiology services, general surgery and anaesthesia, as well as internal medicine and psychiatric services during the day. However, the ED is a level 3 trauma centre with no access to other medical, paediatric, obstetric and surgical specialties and no CT.

### Monitoring the Living Lab

To ensure the Living Lab solutions do, in fact, improve the performance of the rural healthcare system, accountability, in keeping with the quadruple aim, needs to be built in from the start. Our data gathering approach will target the health of the rural population, patient experience of care, quality of work life and cost. We will work with Canadian databases, health ministry and agencies and local health organisation to establish meaningful databases on ED performance indicators, inter-facility transfers and mortality data on emergency sensitive conditions. Chronometric and volumetric healthcare indicators will be tracked over the course of the project and years to come.

### Sustainability and scaling up

The Living Lab is designed to act as a model and a reference for other rural areas that seek to improve their care. At the heart of this initiative is the idea of 'scale up' or increasing the reach and adoption of innovations. Ben Charif *et al* summarises the steps necessary for successful scale up: assessment of scalability (potential for scale up) of the innovation (eg effectiveness, cost-effectiveness), development of a scale up strategy, strategy implementation, strategy evaluation and assuring sustainability.<sup>26</sup> The Living Lab governance structure will ensure that every innovation deployed goes through the steps of scale up. The scale up strategy will also be supported by the Québec, Canadian and international networks set-up around the Living Lab.

## Project 1: Test three user-prioritised solutions in the Living Lab

The literature suggests that a promising way to implement a Living Lab is to proceed iteratively with pilot experimentation projects.<sup>15,19</sup> The pilots bring together stakeholders, build confidence and trust, foster a culture of co-creation, establish mediation processes and demonstrate the first results to facilitate funding. We have already started this process; three solutions have been selected and prioritised by local stakeholders

on the basis of the most urgent needs and on the strength of the environment.

**Project 1a: A creative place where people want to work: improving quality of work life, preventing burnout and optimising recruitment and retention in the Living Lab**

### Background and objectives

The Canadian Medical Association's 2018 National Physician Survey showed alarming rates of physician burnout.<sup>27</sup> Roughly 30% of physicians reported high levels of burnout, 32% of depression and 8% thought of ending their lives in the year previous to the survey. Rates for residents are even higher: burnout 38%, depression 48% and recent suicidal ideation 15%. Emergency medicine physicians and healthcare workers are at a higher risk, with several studies reporting burnout rates of up to 55%.<sup>28</sup> A similar or worse situation has been reported for nurses at provincial, national and international levels. Rates of burnout in rural emergency care providers, however, have not yet been extensively studied.<sup>29</sup>

In this project, we will:

- > assess quality of work life needs at baseline among Living Lab healthcare professionals
- > introduce evidence-based stress management/wellness strategies for healthcare professionals
- > help design and evaluate user-driven wellness interventions to improve quality of work life in the Living Lab.

### Methods

All professionals and staff from Baie-Saint-Paul involved in emergency care will be asked to participate in the project. Quality of work life and burnout levels will be measured psychometrically with '39-item rural emergency recruitment and retention questionnaire' developed by our team will help us identify work satisfaction in several domains including items on continuing education, emergency patients' access to other specialists (eg surgeons), communication quality, relationships with colleagues etc; the 'Quality of Work Life Systemic Inventory (QWLSI)' tool assesses healthcare providers' work conditions at a given time in several domains, their goals within these domains, and the priority attributed to each as well as an indication of the employees' psychological health; and 'burnout' will be measured by the validated 22 item Maslach Burnout Inventory – Health Services Survey (MBI-HSS), its three domains are emotional exhaustion, depersonalisation and personal accomplishment.<sup>22,30,31</sup>

Participants will be offered an informational session on the aspirations of the Living Lab in terms of quality of work life and an introductory intervention session on stress management strategies. Topics presented will include cognitive behavioural strategies focusing on compassion fatigue, resilience, critical incident debriefing, mindfulness, yoga and meditation, information on exercise and the mind and mood, sleep science, self-medication, substance use and misuse, the science of happiness (positive psychology), the best evidence-based recruitment and retention strategies in rural healthcare, top organisational changes for improving quality of work life, and the contribution of arts and creativity.<sup>32</sup> Bibliotherapy (readings on subjects covered) and links to video documentaries will be included.

A survey and focus group will evaluate the intervention and pre-post analysis will be conducted on absenteeism and recruitment and retention.

### *Impact/expected outcomes*

To the best of our knowledge, this is the first specific evidence-based wellness intervention that targets rural healthcare professionals in the Canadian healthcare system. This solution, at the heart of the Living Lab, will lead to a well-established and scalable wellness programme, reduced burnout levels and improved quality of work life, improved recruitment and retention, reduced costs related to work absenteeism, a culture of openness to innovation and creativity, and a database on quality of work life related issues.

### Project 1b: Level of infrastructure and rural innovation: a case study on the implementation of CT

#### *Background and objectives*

The question of the level of diagnostic and therapeutic infrastructure required in rural areas to ensure the safety of care and a better experience for patients and professionals is at the heart of stakeholders' concerns. As the community, healthcare professionals and elected officials in Baie-Saint-Paul have been trying for more than a decade to obtain a local CT scanner and our team was asked to document this project, we chose to use it as a case study to initiate a reflection on the level of infrastructure and its role in rural innovation. Most EDs in the USA and the province of Quebec have this essential equipment to diagnose many acute conditions.<sup>33,34</sup>

The project aims to:

- > describe the efforts deployed so far by healthcare providers and the community to advocate for and justify the purchase and operation of a 24/7 in-house CT scanner in Baie-Saint-Paul Hospital
- > perform a clinical and economic needs analysis for local CT
- > conduct a pre-post study of the impact of a local CT scanner on the number of CT requests, time from CT request to exams, indications for exams, change in the inter-facility transfer patterns, critical care professionals, community, patient and decision-maker satisfaction and economic impact.

#### *Methods*

We will create a descriptive account of the efforts deployed to purchase a CT scanner (media, reports and interviews). Health economic methods will be used to examine the cost of purchasing and operating a CT scanner relative to the potential savings. Inter-facility transfer analysis pre-post CT scanner installation will also be conducted.

### *Impact/expected outcomes*

This case study will initiate a reflection on the notion of the level of infrastructure and its role in rural innovation. The results of this descriptive study will help other communities analyse their decision to purchase a CT scanner and could improve CT access to thousands of rural Canadians currently without it. The experience of mobilisation of an entire population towards the purchase of a CT scanner will bring to light many factors (financial and socio-political) underlying unequal access to healthcare.

### Project 1c: Piloting and evaluating telemedicine with Reacts

#### *Background and objectives*

Inter-facility transfers, common in rural hospitals nationwide, pose many clinical and logistical challenges due to lack of medical personnel to accompany patients. From January to June 2019, 313 inter-facility transfers took place from Baie-Saint-Paul, of which 73 required an escort – most (79%) involving a lengthy 75-minute drive. This priority project proposes to deploy and test a telemedicine application, Reacts (Remote Education, Augmented Communication, Training and Supervision), to offer a distant medical support to nurses in place of a doctor on board of an ambulance. Reacts is a secure digital collaboration platform that enables healthcare professionals to interact dynamically at a distance through secure messaging, interactive assistance and remote procedure monitoring. Designed to meet the highest performance and safety standards, Reacts is used by many hospitals in Canada.<sup>35</sup>

The objectives of this evaluative study are to:

- > describe the implementation of the technology and identify the facilitating factors and challenges related to adoption
- > identify and measure the main effects of the use of technology related to:
  - > clinical practices
  - > the organisation of care and services
  - > efficiency (economic value)
  - > safety
  - > the acceptance and satisfaction of the various stakeholders
- > identify conditions for deployment, sustainability and scaling up.

#### *Methods*

In this mixed-methods case study, data will be collected mainly from existing information sources (management tracking activities and periodic reports on activities), supplemented by questionnaires and interviews on actors' perceptions and satisfaction.<sup>36</sup> Evaluation tools will be developed according to selected indicators.

### *Impact/expected outcomes*

We will develop a rich description of the feasibility and acceptability of Reacts according to stakeholders and clinicians, identify the conditions necessary for its successful adoption and implementation, and explore its potential for sustainability and scale up in a context where many other remote EDs also seek to optimise their inter-facility transfers.

### The future: Prioritising, selecting and deploying other novel solutions

For the purpose of this Living Lab, all of the possible solutions emerging from Rural Emergency Care 360 will be submitted to the Baie-Saint-Paul Living Lab stakeholders, evaluated and prioritised. We briefly present below five examples already identified by stakeholders.

### Potential solution 1: Creating a learning and teaching Living Lab: an *in situ* simulation training programme

#### *The challenge*

New graduates in healthcare identify lack of training and clinical exposure in rural settings as a barrier to rural practice. Rural training settings are a key factor in recruitment and retention and plays a role in patient safety.<sup>37,38</sup> These environments also provide an attractive alternative to busy urban hospitals with too many trainees and limited time to practice technical skills under supervision. However, some suggest that rural hospitals do not provide enough exposure to resuscitation cases or severe trauma requiring procedural skills.

#### *The solution*

We will organise dedicated clinical and procedural skills rotations for emergency medicine specialty residents, College of Family Physicians of Canada (emergency medicine) residents, and for other healthcare students. Trainees as well as local healthcare providers will take part in regular simulation training sessions in a new, *in situ*, state-of-the-art simulation lab. At the same time, trainees will take part in the Living Lab's ongoing innovative research projects, exchange knowledge and experience with local doctors, meet rural residents and take part in community life.

### Potential solution 2: The use of emergency care protocols, prioritising paediatric emergency care

#### *The challenge*

Limited exposure to complex emergency cases as well as information overload contributes to medical errors, especially under stressful practice conditions. The use of well-established treatment protocols standardises care, minimises errors and helps establish confidence and respect in rural practice. Current protocols are not uniformly implemented and updated.<sup>39</sup> In particular, our research shows that the treatment of sick children is highly stressful and that care protocols for this is of high priority for rural care providers.

#### *The solution*

We will deploy the Transfer Emergency Knowledge for Kids (TREKK) protocols and its mobile app. These were developed by leading Canadian paediatric emergency physicians and researchers and a group of leading experts in knowledge translation. TREKK will be used on local computers and mobile devices in the Baie-Saint-Paul Hospital ED and could be beamed onto a giant screen in the resuscitation and trauma rooms.

### Potential solution 3: Telemedicine/teletrauma/telecardiology/telestroke

#### *The challenge*

Limited access to specialists, staff as well as the solo physician practice typical of rural EDs poses a challenge for the management of complex, acutely ill, shock or trauma cases in rural hospitals. Frequent, untimely inter-facility transfers occur because of the real or perceived incapacity to meet the needs of the patient. Some of these transfers could be prioritised and others avoided through telemedicine support.<sup>40</sup>

#### *The solution*

Telemedicine support will be an integral part of the Living Lab. The plan is to equip the trauma and resuscitation rooms with audiovisual equipment and link this to referral centres.

### Potential solution 4: Emergency ultrasound or point-of-care ultrasound

#### *The challenge*

Limited access to formal ultrasound, CT and specialists delays timely management of critical conditions. Our study showed that 75% of rural ED physicians believed that POCUS was an essential tool and skill to master in rural EDs, but few physicians use it regularly.<sup>41</sup> Learning its use is difficult due to little access to continuing medical education.

#### *The solution*

POCUS is a compact and portable ultrasound for evaluating emergency medical conditions in settings such as EDs, where it is used to guide resuscitation and monitor critically ill patients, provide procedural guidance for improved safety and confirm clinical diagnosis. We will organise training and certification to the highest level for every practising physician in the ED in collaboration with the university, continuing education units and the Canadian Association of Emergency Physicians training and via the Reacts platform, which enables the integration of tele-ultrasound.<sup>42</sup>

### Potential solution 5: Solutions from the sky – helicopters and drones

#### *The challenge*

Québec does not have a national helicopter system. In emergency sensitive cases, such as trauma, time is of the essence. Our recent trauma study showed that mortality in rural settings was 3.4 times higher than in urban environments and that 50% of trauma deaths occurred in the pre-hospital setting.<sup>11</sup> Locating victims and preparing timely trauma response and transport is critical. Yet in rural and remote areas it can be difficult to locate victims and deliver the necessary medical equipment (defibrillators and blood products) in a timely manner.

#### *The solution*

Our ongoing Delphi trauma study and rural summit suggest a helicopter med-evac is of high priority. A national private–public helicopter med-evac pilot programme is currently being discussed with the Québec Ministry of Health. Regarding victim location and equipment delivery, the integration of drones into the pre-hospital system could save lives through their ability to transport blood products and defibrillators in emergency situations.<sup>42</sup>

## Conclusion

We are confident that the Baie-Saint-Paul Hospital Living Lab will contribute to saving lives, will improve the quality of work life for rural healthcare professionals, and will inspire similar innovation internationally. To the best of our knowledge, this will constitute the first ever establishment of a rural Living Lab hospital in Canada. We expect that our inclusive, patient and community-centred local model of governance will help attain the quadruple aims of healthcare performance as it evolves. With our large and

experienced interdisciplinary team of investigators, national and international observers, patients and community stakeholders, professional associations and local and provincial government members, we expect that this project will be a success and that these successes will be replicated elsewhere. An undertaking like this is necessarily iterative: both successes and failures will be duly noted and learned from.

This research programme, which is firmly committed to access and quality of care for rural populations, will, I hope, enable me to honour the promise I made as a doctor to my patient from Nelson who asked me to continue fighting for rural populations. By proposing this 'total' project for a rural emergency and envisioning it from the outset as a model to follow and imitate, I hope to enact the truth of this quote, taken from an interview with a doctor conducted as part of the Rural Emergency Care 360 project:

*We always have the impression that innovations are made in the tertiary centre; that's where the research is cutting-edge and all. But precisely because ... it is a little less dogmatic, there are many things here that we do ... that are almost more innovative than what I have seen in the city. ■*

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