Over the past century, antimicrobials have evolved from the panacea for bacterial infections to an endangered tool because of rising resistance. Resistant bacteria in animals are one source of antimicrobial resistance (AMR) for humans—our strongest connection to animals is our daily food. The present report summarized and evaluated the scientific knowledge and pertinent national policies on AMR and antimicrobial use (AMU) in pigs and chickens.

The three objectives of the present report were as follows: first, to serve as a reference for public health, regulatory and agricultural policy-makers when debating this topic; second, to inform public health practitioners of notable AMR risks to the Canadian population related to food and agriculture; and third, to identify key research and policy gaps that compromise our ability to control this problem.

The literature cited in the present comprehensive review was identified by systematically applying a priori search strings and medical subject headings, developed by the authors in conjunction with a professional librarian, to citation databases (Agricola, CAB, EMBASE, Medline and Scopus). Citations were restricted to English-language publication since 1990. After the removal of duplicates, more than 2000 potentially relevant citations were downloaded into commercially available software (RefWorks, USA). Titles were independently reviewed by two veterinary epidemiologists, and pertinent publications were reviewed in full. Additional ad hoc searches were conducted to identify grey literature or address specific questions. In total, 539 documents were cited.

Humans can acquire antimicrobial-resistant bacteria from animals through food, but the risks of clinical disease, bacteria transmission to humans and horizontal transmission of resistance elements from bacteria in food to bacteria in the human intestinal tract have not been quantified. Likewise, the relative amounts that AMU in animals and humans each contribute to AMR in bacteria carried by humans have not been quantified. To address these questions, future research should expand on both ends of the current farm-to-fork research continuum. This could be achieved by studying the human health outcomes that help or hinder the emergence and persistence of resistance. Evidence of increased resistance with increased AMU has been far more consistent than evidence of decreased resistance following cessation of use. Incomplete understanding of selective pressures for resistance in livestock, AMR transmission rates between animals and people, and management practices that help or hinder the emergence and persistence of resistance on farms has made evaluating the risk posed by AMU in livestock to public health contentious. Consequently, evidence-based interventions have been elusive and controversial.

Links through travel and trade have made AMR in people and animals a global problem. International agencies have supported national solutions to this worldwide issue through prudent AMU guidelines, surveillance strategies and standardized risk-assessment techniques. Canada has established an integrated AMU and AMR surveillance program in humans and livestock while eliminating inappropriate AMU practices and still ensuring economic viability of the industry.

The causal relationship between AMU and AMR is complex. Use of some antimicrobials in some species in certain situations has clearly resulted in resistance in some bacteria. However, what has happened with one animal species, bacterium, antimicrobial or management system has not always happened in others. Evidence of increased resistance with increased AMU has been far more consistent than evidence of decreased resistance following cessation of use. Incomplete understanding of selective pressures for resistance in livestock, AMR transmission rates between animals and people, and management practices that help or hinder the emergence and persistence of resistance on farms has made evaluating the risk posed by AMU in livestock to public health contentious. Consequently, evidence-based interventions have been elusive and controversial.

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Antimicrobials are the necessary tool for appropriate veterinary care of food animals. Certainly, some AMU could be eliminated while still humanely raising animals; however, data are lacking on the reasons why antimicrobials are used and the need for prophylactic and metaphylactic AMU to protect animal welfare. This has made distinguishing between necessary and inappropriate AMU contentious. The agriculture industry and regulators must continue to address this problem together so that AMU policy can preserve appropriate AMU, thus ensuring the production of safe food and humane rearing of livestock while eliminating inappropriate AMU practices and still ensuring economic viability of the industry.

The outcomes of such research would enable policy and interventions to expand from a specific focus on AMU and AMR to improving overall food safety.
antimicrobial access and use, but this process has been slow and leaves much to be done. The Canadian government is responsible for ensuring the health of Canadians through policies and regulations that ensure safe food production. It must carry out this responsibility, while concurrently supporting a sustainable livestock industry that can produce food in a financially and environmentally sound manner. This task requires continued commitment to evidence-based policy and advocating for other nations to do the same.

At the time of the present report, no prudent AMU education programs for producers or nutritionists existed in Canada. Education is desperately needed for the people who initiate much of the agricultural AMU in Canada. Yet concerns over inappropriate AMU have often overshadowed the good news stories in the industry. Agriculture and veterinary medicine have made advancements in animal health that decrease their reliance on antimicrobials. Livestock producers have embraced improvements in sanitation, nutrition and vaccine technology. Biosecurity has enabled flocks and herds to become negative for diseases that are endemic in the industry – diseases that were traditionally controlled with antimicrobials. Producer organizations have taken a proactive stance on food safety. Both chicken and pork industries have self-mandated on-farm food safety programs. These programs support best management practices and appropriate AMU. In conjunction with these farm-based improvements, the slaughter and meat processing industry has made substantial advancements in reducing the bacterial contamination of meat. In North America, the rate of foodborne diseases declined after slaughter and processing plants implemented hazard analysis and critical control point systems. These interventions have undoubtedly decreased the burden of illness in people from resistant bacteria in food, but the gains have not been quantified because our surveillance typically ends at ‘the fork,’ rather than with health outcomes.

Although great progress has been made, there is still an enormous amount of work to be completed. We have advocated for continued research, but have also recognized that such research is ineffective without improvements in knowledge management. Novel techniques must be found to systematically assimilate the immense volume of discrepant research, ensure results are evaluated in context, and distribute the contextualized output to practitioners and policy-makers. Beyond this, the main recommendations from the present report were as follows:

- Seek and support research on the effectiveness of interventions including, but not limited to, AMU withdrawal to mitigate existing AMR.
- Seek and support research that expands on the current ‘farm-to-fork’ approach to account for diverse human health outcomes.
- Advocate for fair, transparent veterinary drug regulations, and AMR and AMU monitoring around the world based on scientific evidence, risk assessment, and appropriate precaution to ensure free and open trade of safe meat products.
- Commit to transparent policy evaluation to ensure Canada’s veterinary drug regulations result in prudent and safe AMU.
- Deliver AMU education to producers and nutritionists.
- Foster an innovative and collaborative relationship among regulators, public health officials and the agriculture industry.