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Review

# Opportunities and challenges for the application of microfluidic technologies in point-of-care veterinary diagnostics

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ABSTRACT

There is a growing need for low-cost, rapid and reliable diagnostic results in veterinary medicine. Point-of-care (POC) tests have tremendous advantages over existing laboratory-based tests, due to their intrinsic low-cost and rapidity. A considerable number of POC tests are presently available, mostly in dipstick or lateral flow formats, allowing cost-effective and decentralised diagnosis of a wide range of infectious diseases and public health related threats. Although, extremely useful, these tests come with some limitations. Recent advances in the field of microfluidics have brought about new and exciting opportunities for human health diagnostics, and there is now great potential for these new technologies to be applied in the field of veterinary diagnostics. This review appraises currently available POC tests in veterinary medicine, taking into consideration their usefulness and limitations, whilst exploring possible applications for new and emerging technologies, in order to widen and improve the range of POC tests available.



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## 1. Introduction

Point-of-care (POC) diagnostics is an area that has attracted considerable attention in the last decade. Testing at POC means that analytical procedures are carried out at the side of or near to the patient [1], for this reason, it is also sometimes referred to as "bedside" testing [2]. The reasons for the considerable interest in the field of POC testing are numerous: the potential to decrease costs of diagnosis [3], increasing the accessibility of these types of test to disadvantaged populations [4], and reducing the time between sampling and a treatment decision [5].

Following the global trend towards more affordable and accessible diagnostic testing, the Sexually Transmitted Diseases Diagnostics Initiative (SDI) within the World Health Organization (WHO) recently established a set of benchmark criteria for the ideal rapid test, under the acronym "ASSURED" [6]: Affordable, Sensitive, Specific, User-friendly (simple to perform in a few steps, with minimal technical training), Robust and rapid (results available in less than 30 min), Equipment-free, Deliverable to those who need them. Ideally, POC tests should respect all or as many as possible of these characteristics [7].

## 2. Point of care testing and its scope in veterinary medicine

In the veterinary area, there is a similar need for low-cost, reliable and rapid diagnostic tests to be carried out at the POC [8]. So called on-site or animal-side tests will have considerable advantages over laboratory-based testing, which usually involves laborious and expensive laboratory techniques and dedicated technical personnel. All of the analytical processes involved in testing, from collection of the sample to communication of the results, could potentially be performed in a single step, considerably reducing the time between testing and treatment [9]. This can translate into more affordable veterinary care, reduced handling of animals, targeted treatments and rapid testing in more remote geographic areas.

The need for more affordable, rapid and accessible tests is a recurrent theme in the literature, in particular as an invaluable tool in dealing with diseases that either represent a threat to public health [10], have substantial impact on animal welfare [11] and/or are of economic importance [12], with particular relevance to situations where laboratory facilities and funds are limited [13]. Furthermore, the general globalisation of trade of animals and animal products has greatly increased the risk of rapid and wide-ranging spread of emerging and exotic diseases, requiring timely and efficient ways of dealing with diseases that could have catastrophic repercussions for the individual farmer, as well as economic implications for the entire country and international trade [14]. In situations concerning disease outbreaks, where rapid propagation of infectious agents and/or high mortality are salient features, as in the case of the highly pathogenic H5N1 strain of avian influenza virus, a rapid "animal-side" test would represent a critical tool for both collecting surveillance data and for assisting in the control of outbreaks [11,15]. Currently available veterinary POC tests offer a good opportunity for a truly "animal-side" diagnosis, but the analytical performances of "on-site" testing are still considered limited compared with laboratory-based testing [16], whilst the possibility offered by the support of a central laboratory in the interpretation of the results is still perceived as critical [17]. Recent advances in microfluidic technologies for POC testing in the human field could overcome these hurdles and might be applied in veterinary medicine. This review aims to appraise the current status of POC testing in veterinary medicine, describing their advantages and limitations, whilst also assessing the potential of microfluidic technologies to improve existing POC tests and solve some of their intrinsic limitations.

## 3. Point-of-care devices currently available in veterinary diagnostics

At present, the most widely used technologies for POC testing in veterinary medicine are: dipstick tests and lateral flow immunoassays.

### 3.1. Dipstick and strip test

These assays are based on the principle of immunoblotting and are made of paper strips with pads to analyse specific fluids. After the sample is introduced, the results are compared with a colour-coded chart to provide a semi-quantitative determination of the analyte(s). The most commonly used are test strips developed for human urine analysis, allowing the simultaneous detection or monitoring of leukocytes, nitrite, urobilinogen, protein, pH, haemoglobin, specific gravity, ketones, bilirubin and/or glucose (Fig. 1) [18]. While it has been developed for human patients, there is a high correlation between the dipstick results and other routinely used methods for urine analysis, which has resulted in this test being widely used in small animal private practice for first-line diagnosis of chronic kidney disease, mainly through an

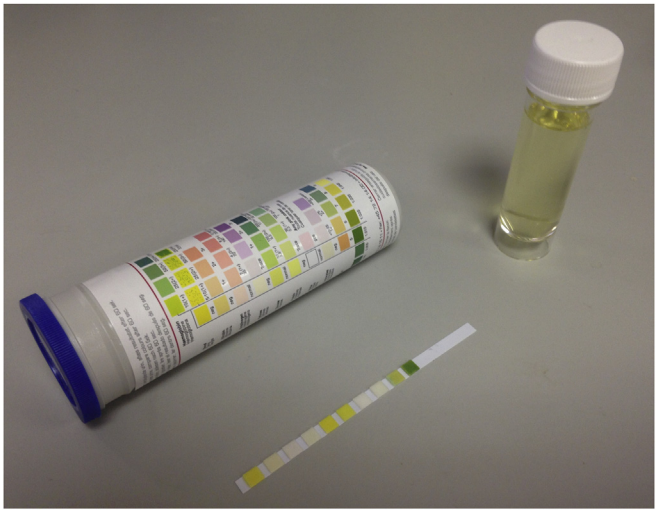

**Fig. 1.** Urine analysis performed using a dipstick test. The test strip is immersed in the urine sample for a few seconds, and, after a few minutes, the colour resulting from the reaction can be visually compared against the chromatic scale provided.