



First-void urine as a game-changer for HPV-based cervical cancer screening

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INTRODUCTION

Cervical cancer is the fourth most common cancer in women, worldwide leading to over 300,000 deaths per year.¹ Introduction of screening programs has allowed for an increased detection of pre-cancer lesions, resulting in a 50% reduction of premature deaths. Yet, non-attendance rates are high: on average 40% of women living in developed countries are not participating in screening, and 80% in developing countries.²

The golden standard to screen for pre-cancer lesions has been cytologic evaluation based on clinician-taken cervical smears. Reasons for reluctance to gynecological examinations are the relative invasive character of cervical sampling, ethnicity and culture, lack of time and the need to visit a clinician. The principal cause of cervical cancer are high-risk infections with the human papillomavirus (HPV) and a significant evidence-base has been established to indicate that HPV-based cervical cancer screening is more effective and efficient.³

This is where Novosanis' Colli-Pee®, a user-friendly, self-sampling urine-capturing device fits in with the opportunity to offer a complete molecular approach towards cervical cancer screening. Colli-Pee® collects first-void urine (first 20 mL of urine flow) for the detection of HPV infections. The same sample also has great potential for molecular-based triage testing to differentiate between a transient productive infection and a persistent transforming infection.⁴

STANDARDIZED FIRST-VOID AND VOLUMETRIC URINE SELF-SAMPLING

First-void urine contains washed away mucus and debris from exfoliated superficial cell layers of a cervix carcinoma. Colli-Pee® allows for volumetric and standardized collection of first-void urine and different variants enable collection of different volumes ranging from 45 mL to 4 mL. The volumetric collection capabilities of the device have been measured - 84.8% and 89.4% of the collected samples are within the specified range of 20±2 mL and 10±1 mL respectively.⁵ This is significantly more standardized compared to a regular urine cup, where collected sample volumes are only 15.1% within the specified range. Moreover, Colli-Pee® outperforms a regular urine cup with regards to the number of both human and HPV DNA copies found in urine.^{6,7} This is illustrated on Figure 1 for HPV 16 DNA copies specifically.

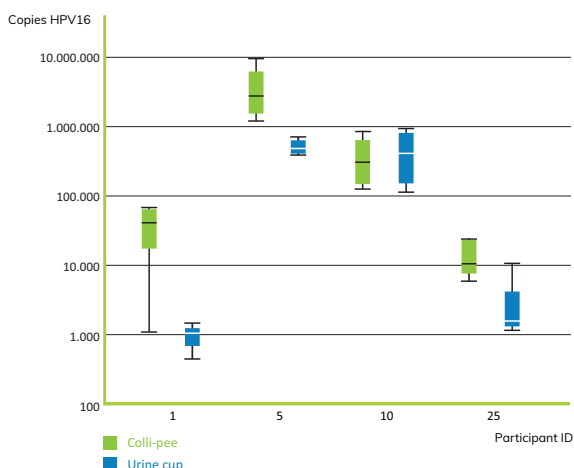


Figure 1
Boxplots of HPV 16 DNA copies, for all patients where an infection with HPV 16 was detected, found in Colli-Pee® versus copies found in a urine cup.

Novosanis' usability study also showed that Colli-Pee® is a well-accepted solution for home-based collection: 96% of users rated the device as easy-to-use and 87% preferred postal delivery to visiting a physician.⁸

FEASIBILITY OF COMMERCIAL AVAILABLE DIAGNOSTIC ASSAYS

Several pilot studies confirmed feasibility of HPV DNA detection in first-void urine with commercially available diagnostic assays for automated screening (Roche Cobas® HPV, BD Onclarity™ HPV, Aptima® HPV Hologic Panther, Cepheid Xpert® HPV) or genotyping (Genefirst Papilloplex™ HR-HPV, Anyplex™ II HPV HR Seegene, Fujirebio Innolipa™, High+Low PapillomaStrip Operon).^{9,10,11,12,13,14,15,16}

These studies have been carried out with Colli-Pee® pre-filled with Urine Conservation Medium (UCM®), enabling general urine preservation for transport and storage at ambient temperature for up to 7 days.¹⁷ Detection of HPV DNA in Colli-Pee® collected first-void urine was assessed with commercial, diagnostic assays and both an in-house and a commercially available genotyping assay as a reference.

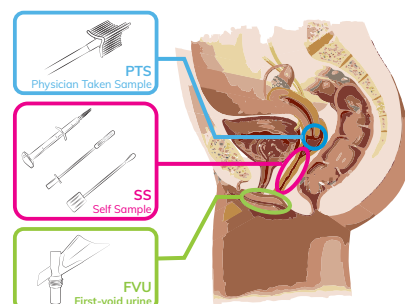
NucliSENS® easyMag® extraction was used for analysis with the two comparator assays that were developed to provide maximal analytical sensitivity: (a) a lab developed HPV type specific qPCR method i.e. the Riatol assay (UAntwerp, Belgium) and (b) the Optiplex HPV genotyping kit (Diamex, Germany).

Concordance between the tested and comparator assays show a high level of agreement for genotyping tests with kappa-values ranging from 0.67 to 0.82.^{10,11,12} Automated screening assays also demonstrate fair to good concordance with kappa-values ranging from 0.24 to 0.76 for detection of all HPV types.^{13,14,15,16} When HPV 16 and HPV 18, the most commonly detected high-risk types in cervical cancer, were under investigation, kappa-values slightly increased i.e. 0.56 to 0.73.^{13,14,16} This already shows the clinical feasibility of first-void urine in primary screening.

CLINICAL PERFORMANCE DATA FROM COLPOSCOPY REFERRAL POPULATIONS

Several clinical trials have been set-up, in more than 2500 women referred to colposcopy, to address the performance of Colli-Pee® collected first-void urine to other self-sampling devices for HPV detection and understand its potential in cervical cancer screening.

The EVAH study, using the analytically sensitive SPF10-DEIA-LiPA25 assay and the clinically validated GP5+/6+ assay (EIA) for HPV detection, showed that urine samples collected with Colli-Pee® enabled almost perfect detection of HPV infections in women with CIN2+ lesions.¹⁸ This is illustrated on Figure 2 by an absolute sensitivity ranging from 95% to 100%. The quality of clinician-taken smear and a vaginal swab self-sample were also assessed within the EVAH study. These samples provided perfect sensitivity, similar to first-void urine collected with Colli-Pee®.





Absolute sensitivity: HPV-detection in CIN2+ women



Absolute specificity: no HPV in women without CIN2+

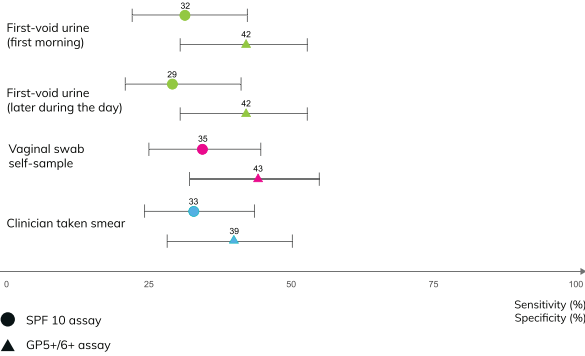


Figure 2

Absolute sensitivity and specificity results of the EVAH study in clinician-taken smear, vaginal swab self-sample and first-void urine with CIN2+ diagnosis as reference. Sensitivity i.e. HPV detection rate in CIN2+ women; specificity i.e. percentage not infected with HPV and not diagnosed with CIN2+.

The EVAH study also showed high concordance between HPV detection in first-void urine and clinician-taken smears illustrated by kappa-values ranging from 0.75 to 0.85. This corresponds to preliminary results of ongoing clinical trials where kappa-values up to 0.80 have been observed.^{19,20}

About 90% of HPV infections clear within two years and only a small proportion of infections can persist and progress to cervical cancer.²¹ Hence, HPV-based primary screening provides low specificity for the selection of clinically relevant lesions. Results of the EVAH study also showed modest specificity rates for all sample types i.e. 33% to 39% for clinician-taken smear, 35% to 43% for the vaginal swab self-sample and 29% to 42% for first-void urine collected with Colli-Pee® (Figure 2).

The VALHUDES study aims to assess the sensitivity and specificity of particular hrHPV assays in vaginal self-samples as well as first-void urine compared to matched physician-taken samples.²² Data using the hrHPV testing with Abbott RealTime High Risk HPV assay demonstrated that first-void urine collected at home using Colli-Pee® containing UCM showed similar accuracy for detecting CIN2+ compared to cervical samples taken by a clinician. These results are pivotal to improve sampling strategies and reach women who do not participate in traditional screening programs by offering urine self-collection at home.^{23,24}

The Predictors 5.1 study compared five different sampling methods through vaginal self-sampling devices and urine for HPV testing among a population of women referred for colposcopy. Similar positivity rates and sensitivities for CIN2+ and CIN3+ were seen for flocked swab, Dacron swab and urine. Women found urine as a sample easiest to collect and were more confident they had taken the sample correctly using this method.²⁵

MORE EXCITING RESULTS IN THE PIPELINE

In the ongoing CASUS trial new molecular approaches are being developed that enable triage on the same urine sample based on methylation markers. These findings forecast the development of fully molecular cervical cancer screening approaches where Colli-Pee® delivers a solid sampling solution.

The CASUS trial also investigates the impact of collection volume of our new variants (10 mL and 4 mL) and DNA extraction method on the detection of biomarkers and HPV DNA in first-void urine. First data showed an overall good agreement between the three different first-void urine collection volumes for human DNA and HPV DNA endpoints. Consequently, the Colli-Pee® Small Volumes variant was selected for the remainder of the study as it is compatible with high-throughput instruments and postal delivery, offering potential for high-throughput screening and home-based sample collection.²⁶

For more information: www.novosanis.com

References:

- (1) Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin.* 2018;68(6):394-424. doi:10.3322/caac.21492
- (2) Gakidou E, Nordhagen S, Obermeyer Z. Coverage of cervical cancer screening in 57 countries: Low average levels and large inequalities. *PLoS Med.* 2008;5(6):e132. doi:10.1371/journal.pmed.0050132
- (3) Arbyn M, Snijders PJF, Meijer CJLM, et al. Which high-risk HPV assays fulfil criteria for use in primary cervical cancer screening? *Clin Microbiol Infect.* 2015;21(9):817-826. doi:10.1016/j.cmi.2015.04.015
- (4) Snoek BC, Splunter AP, Bleeker MCG, et al. Cervical cancer detection by DNA methylation analysis in urine. *Sci Rep.* 2019;9(1). doi:10.1038/s41598-019-39275-2
- (5) Meers N, Donné J, Beyers K, et al. Standardized and volumetric collection of first-void urine for detection of STIs and HPV: A comparison between Colli-Pee and a standard urine cup. *Eurogin.* 2019.
- (6) Vorsters A, Van Keer S, Biesmans S, et al. HPV DNA detection in urine: Effect of a first-void urine collection device and time of collection. *IPVC.* 2015.
- (7) Pattyn J, Van Keer S, Biesmans S, et al. Human papillomavirus detection in urine: Effect of a first-void urine collection device and timing of collection. *J Virol Methods.* 2019;264:23-30. doi:10.1016/j.jviromet.2018.11.008
- (8) Donné J, Beyers K, Urlings J, et al. Human factors engineering to drive the design and development of a next generation Colli-Pee home-based first-void urine collection. *World IUSTI.* 2019.
- (9) Pattyn J, de Koeijer M, Van Keer S et al. Pilot study on the use of INNO-LiPA® HPV Genotyping Extra II with ColliPee™ collected UCM preserved urine. *Eurogin.* 2017.
- (10) Vorsters A, Pattyn J, Van Keer S, et al. Preliminary evaluation of the High+Low PapillomaStrip assay with Colli-Pee® collected UCM preserved urine. *Eurogin.* 2018.
- (11) Vorsters A, Pattyn J, Vankerckhoven V, et al. Compatibility of a single closed tube real-time PCR assay for testing first void urine specimens. *IPVC.* 2017.
- (12) Vorsters A, Vankerckhoven V, Kapadia D, et al. Compatibility of Genefirst Papilloplex™ HR-HPV genotyping assay for testing first void urine specimens. *Eurogin.* 2016.
- (13) Vorsters A, Deswert K, Schiettekatte G, et al. Evaluation of the Roche COBAS 6800 HPV assay with Colli-Pee collected, UCM preserved Urine. *Eurogin.* 2017.
- (14) Vorsters A, Van Keer S, Biesmans S, et al. Evaluation of the Roche COBAS HPV assay with Colli-Pee collected, UCM preserved Urine. *Eurogin.* 2016.
- (15) Vorsters A, Vankerckhoven V, de Koeijer M, et al. Performance of an Automated HPV Genotyping Assay using First Void Urine Specimens. *IPVC.* 2015.
- (16) Vorsters A, Vankerckhoven V, Van Keer S, et al. Pilot feasibility study on use of Cepheid Xpert HPV with Colli-Pee collected UCM preserved urine. *Eurogin.* 2016.
- (17) Meers N et al. Storage and transport recommendations for first-void urine samples. <https://novosanis.com/sites/default/files/poster/pdf/Storage%20and%20transport%20recomm%20for%20first-void%20urine%20samples.pdf> 1626334034
- (18) Leeman A, del Pino M, Molijn A, et al. HPV testing in first-void urine provides sensitivity for CIN2+ detection comparable with a smear taken by a clinician or a brush-based self-sample: cross-sectional data from a triage population. *BJOG An Int J Obstet Gynaecol.* 2017;124(9):1356-1363. doi:10.1111/1471-0528.14682
- (19) Martinelli M, Musumeci R, Crotti C, et al. New strategies in cervical cancer screening: evaluation of accuracy of HPV-testing on vaginal and first-void urine self-samples versus clinician-collected cervical samples. *PHE.* 2019.
- (20) Vanden Broeck D, Van Keer S, Peeters E, Vorsters A, Arbyn M, Benoy I. Analytical performance of Abbott RealTime HighRisk HPV assay on first-voided urine samples versus physician-collected cervical samples. *Eurogin.* 2019.
- (21) WHO. [www.who.int/news-room/fact-sheets/detail/human-papillomavirus-\(hpv\)-and-cervical-cancer](http://www.who.int/news-room/fact-sheets/detail/human-papillomavirus-(hpv)-and-cervical-cancer).
- (22) Arbyn M, Peeters E, Benoy I, et al. VALHUDES: A protocol for validation of human papillomavirus assays and collection devices for HPV testing on self-samples and urine samples. *J Clin Virol.* 2018;107:52-56. doi:10.1016/j.jcv.2018.08.006
- (23) Van Keer S, Peeters E, Vanden Broeck D, De Sutter P, Donders G, Doyen J, Tjalma WAA, Weyers S, Vorsters A, Arbyn M. Clinical and analytical evaluation of the RealTime High Risk HPV assay in Colli-Pee collected first-void urine using the VALHUDES protocol. *Gynecol Oncol.* 2021 Jun 22;S0090-8258(21)00490-X. doi:10.1016/j.ygyno.2021.06.010.
- (24) Van Keer S, van Splunter AP, Pattyn J, De Smet A, Herzog SA, Van Ostade X, Tjalma WAA, Ieven M, Van Damme P, Steenberg RDM, Vorsters A. Triage of human papillomavirus infected women by methylation analysis in first-void urine. *Sci Rep.* 2021 Apr 12;11(1):7862. doi:10.1038/s41598-021-87329-1.
- (25) Cadman L, Reuter C, Jitlal M, Kleeman M, Austin J, Hollingworth T, Parberry AL, Ashdown-Barr L, Patel D, Nedjai B, Lorincz AT, Cuzick J. A Randomized Comparison of Different Vaginal Self-sampling Devices and Urine for Human Papillomavirus Testing-Predictors 5.1. *Cancer Epidemiol Biomarkers Prev.* 2021 Apr;30(4):661-668. doi:10.1158/1055-9965.
- (26) Téblick L, Van Keer S, De Smet A, Van Damme P, Laeremans M, Rios Cortes A, Beyers K, Vankerckhoven V, Matheussens V, Mandersloot R, Floore A, Meijer CJLM, Steenberg RDM, Vorsters A. Impact of Collection Volume and DNA Extraction Method on the Detection of Biomarkers and HPV DNA in First-Void Urine. *Molecules.* 2021 Apr 1;26(7):1989. doi:10.3390/molecules26071989.