APPLIED SCIENCES GROUP

> Whilst continuing to push forward to deliver cutting-edge scientific services, we remain clear that our mission is first and foremost to serve the administration of justice and safeguard public health.



NEW AND IMPROVED TECHNIQUES

We are always refining and enhancing our techniques in the pursuit of higher efficiency.

NEW METHOD TO PROCESS SAMPLES FOR HUMAN IDENTIFICATION

Processing hard tissue samples such as bone and teeth in mass fatality incidents (MFI) is a difficult task that often yields less than satisfactory results.

To improve our chances of successfully obtaining DNA profiles, we have implemented a new two-pronged method, which involves machine pulverisation of samples, as well as a semi-automated DNA extraction protocol.



while improving the likelihood of obtaining a DNA profile



DETECTING CONTAMINATION IN RIFAMPICIN PRODUCTS

In February 2020, our overseas counterparts alerted us to the potential contamination of I-nitroso-4-methylpiperazine (MNP) in rifampicin drug substances. As there were no standard tests for such analysis available internationally, we proceeded to develop our own testing methodologies.

Our dedicated team was able to quickly develop a Liquid Chromatography Hybrid Tandem Mass Spectrometry (LC-MS/MS) test to quantitate the presence of MNP in rifampicin products.

As of March 2021, a total of



been analysed using our test method, producing responsive analytical results that have enabled us to take appropriate regulatory actions

rifampicin products

in Singapore have

INSIGHTS TO METABOLISM OF NEW PSYCHOACTIVE SUBSTANCES (NPS)

Some of the challenges that we face in supporting enforcement agencies to detect the abuse of new psychoactive substances (NPS) include the constant emergence of new substances, as well as limited published metabolism data about such drugs.

To tackle this issue, we collaborated with the National University of Singapore Pharmacy Department and the Faculty of Pharmaceutical Sciences from Ghent University, Belgium on an in vitro drug metabolism study that uses human liver microsomes (HLM) to identify NPS biomarkers.

The result of this research project was published in the Archives of Toxicology in November 2020.



RISING TO THE

CHALLENGE



ENHANCED DNA METHODOLOGIES

Faster and more accurate DNA age prediction models

In 2017, we successfully developed a model which could predict the age of a person based on a blood stain.

Building upon that achievement, we have now come up with two new prediction models using an artificial neural network (machine learning) algorithm. The results of this project have since been published in a Nature Portfolios Journal — Scientific Reports.



We are now able to better support the police with valuable DNA intel through our new prediction models, which:



First Y-STR profiling evaluation system in the world

At HSA, a small team of four forensic DNA scientists process close to 5,000 Y-STR DNA profiles each month.

To maximise efficiency, we implemented an expert system to automatically evaluate Y-STR profiles. This system requires minimal human input and automatically highlights samples with quality issues to the scientist for review.



CHIROPTICAL METHOD IN CHIRAL DRUG ANALYSIS

The problem:

Identification of the active isomer is a crucial part of the pharmaceutical analysis of chiral drugs. However, previous analysis methods, using specialised chiral columns, were expensive and time-consuming.

Our solution:

01

02

We developed a chiroptical test method that allows us to use the common liquid chromatographic separation technique to analyse a wide range of chiral drugs.

STREAMLINING THE DETECTION OF TOXICOLOGICALLY RELEVANT DRUGS

In September 2020, we developed, validated and implemented a comprehensive screening and quantitation method for 🗖 **5** toxicologically relevant drugs in blood

This new method, which uses liquid chromatography with



Can also simultaneously screen for **Provides faster results and** drugs value for **S** using automated library testing for our clients

searching software

RISING TO THE

CHALLENGE

Our improved testing methodology has resulted in a

reduction in analysis time

quadrupole time-of-flight mass spectrometer (LC-QTOF/MS):

Has ml of sensitivity 🖌 blood. and confirmative m power previously

OUR COVID-19 RESPONSE

Over the year-in-review, we remained adaptable and responded promptly to the constantly evolving **COVID-19** situation.

HANDLING OF DECEASED COVID-19 PATIENTS

This past year, we worked closely with the Coroner's Court and the Singapore Police Force (SPF) to modify our existing work processes for safe transfer and handling of deceased persons who had or were suspected to have COVID-19.

These modifications relate to:



We also held conversations with SPF regarding the handling of COVID-19 homicide cases, and provided our recommendations on the collection of evidence for forensic testing.

These newly modified processes and guidelines are not restricted to COVID-19 and will be useful in future pandemics.





COVID-19 AND HAND SANITISERS

Due to a global shortage of pharmaceutical-grade ethanol during the COVID-19 pandemic, some manufacturers began to use lower-grade ethanol in their hand sanitiser products. To ensure public safety, we developed an analytical method utilising Gas Chromatography-High Resolution Accurate Mass (GC-HRAM) technology to detect a range of impurities in hand sanitisers.





were recalled

Products that were found to contain **evels** of impurities or adulterated with methanol



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KNOWLEDGE AND INNOVATION

RISING TO THE

CHALLENGE

We push the boundaries of knowledge to stay at the forefront of scientific advancements.

GAINING INSIGHTS ON DNA DEPOSITION

We are often approached by the courts to explain what affects DNA deposition. A key factor is the concept of "shedder status", which categorises individuals based on their propensity to deposit DNA via contact with a surface. Till now, studies on shedder status have largely been based on short-term data.

To better support the courts and to gain further insights into this aspect of DNA deposition, we began a longitudinal study which followed the changes in shedder status of participants after a one-year interval. The study was presented at the 2020 Asian Forensic Sciences Network (AFSN) DNA workgroup.

LOCALISED DATA ON DNA MIXTURE PROFILES

Estimating the number of persons who contribute to a DNA mixture profile can be challenging due to a lack of data outside the Caucasian population. Hence, to better assist forensic DNA scientists in the region, we began a study on the use of simulated DNA mixture profiles based on the local Chinese, Malay and Indian populations.

Through this study, we now have novel insights about the impact of allele dropout and the differences between intra-ethnic and inter-ethnic DNA mixtures. These key findings have since been published in Scientific Reports (a Nature Portfolio journal).

INTER-LABORATORY STUDY ON CANNABIS PRODUCTS

The interpretation of the legality of cannabis products varies globally as a result of different quality control standards being developed and published in various pharmacopoeia.

Seeking greater alignment, the Laboratory Coordination and Scientific Support Unit of Health Canada organised an international collaborative study to determine specific cannabinoids (tetrahydrocannabinol, tetrahydrocannabinolic acid, cannabidiol and cannabidiolic acid) in cannabis products.

HSA was one of the participants in this study, which together with other government laboratories from Canada, Germany, UK, Australia, USA, The Netherlands and Switzerland are working to establish an internationally recognised testing approach.

The outcome of this study will be presented at international meetings involving regulatory groups, such as the International Laboratory Forum on Counterfeit Medicines, the Permanent Forum on International Pharmaceutical Crime and OMCL Network.



ASSESSING AUTOMOTIVE PAINT EVIDENCE

Recognising the data gaps that exist in our local population studies, especially in automotive distribution, we embarked on several automotiverelated projects.

These studies have helped us to better understand automotive paint characteristics and its significance in casework, as well as evaluate the discriminating power of our laboratory's standard paint examination protocol, which consist of visual and microscopical examinations, Fourier Transform Infrared (FT-IR) Spectroscopy and Scanning Electron Microscopy with Energy Dispersive X-ray (SEM/EDX) Spectroscopy.

The discrimination study consisted of a comparative analysis of 256 paint samples from six colour groups.





SHARING OUR EXPERTISE

In the spirit of cooperation, we continued to share our knowledge and expertise with the local and international community.

DNA DATABASING AND Y-STR ANALYSIS

In September 2020, we were invited to share our experiences in DNA databasing and Y-STR analysis at the 44th European Network of Forensic Science Institutes (ENFSI) DNA Working Group meeting.

Topics that we presented included our implementation of Y-STR analysis and statistical evidence to support law enforcement agencies, the insights on various statistical calculation methods, as well as the possibility of using Y-STRs to accurately predict ethnicity using a machine learning model.

At the virtual 26th Annual National CODIS Conference in December 2020, we had the opportunity to present to the international community updates such as our recent establishment of the Y-STR database, as well as our implementation of the automatic profile evaluation system, which cuts the time taken to analyse Y-STR profiles by up to 65%.





DNA ANALYSIS OF SEXUAL ASSAULT EXHIBITS

For the first National Sexual Assault Training virtual workshop organised by National University Hospital (NUH) and CID's Specialised Sexual Crimes Branch (SSCB) in February 2021, HSA was invited to deliver a presentation on the handling of sexual assault evidence.

Topics that were covered during this session included an overview of forensic DNA techniques with a special focus on semen and DNA testing, current research initiatives undertaken to improve the analysis of sexual assault evidence, and overseas guidelines relating to the medical examination of sexual assault patients.

CRIMINAL LEGAL AID SCHEME (CLAS) TRAINING

In August and September 2020, we conducted two virtual training sessions on drug abuse and DNA testing, where a total of over 400 criminal lawyers attended. The sessions helped these practising lawyers gain a better understanding of how HSA conducts testing in these areas.



RISING TO THE

CHALLENGE



DVI WORKSHOP

In December 2020, the Singapore Police Force organised the inaugural Disaster Victim Identification (DVI) Preparatory Workshop, which aims to equip designated personnel with the knowledge and skillsets for DVI operations during mass fatality incidents.

As part of the workshop, HSA was invited to facilitate a session on the use of DNA in identification. The session covered both theory and practical components.

The workshop was attended by over

NUH staff,

as well as counterparts from the Attorney-**General's Chambers** (AGC) and SSCB

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SUPPORTING SPECIAL OPERATIONS COMMAND

In September 2020, we provided technical support and consultation to the Special Operations Command and HTX's Weapons & Armament, Platforms Systems Sustainment Centre for their ammunition research at the Gurkha Cantonment range. A high-speed camera was used to obtain impact footage and calculate the projectile's speed.

COLLABORATION WITH IMMIGRATION & CHECKPOINTS AUTHORITY (ICA)

In December 2020, we started a two-year collaboration with the Identity Authentication & Document Analysis Branch (IADA) of ICA on the examination of travel and identity documents. We plan to establish a framework for knowledge sharing and to build a database on common security features and forgeries found in such documents.

DELIBERATING ON WHO-ECDD RECOMMENDATIONS FOR CANNABIS AND CANNABIS-RELATED SUBSTANCES

From 2019 to 2020, we were part of an inter-agency committee comprising Attorney-General's Chambers (AGC), Ministry of Foreign Affairs (MFA), Ministry of Health (MOH), Central Narcotics Bureau (CNB) and Ministry of Home Affairs (MHA), which was set up to deliberate on the World Health Organization Expert Committee on Drug Dependence's (WHO-ECDD) recommendations on cannabis and cannabis-related substances.

Our contributions included providing technical advice, as well as participating in the Commission on Narcotic Drugs (CND) meetings as part of the Singapore delegation.

TRAINING SERVICES

In the past year, HSA has expanded its training services to include the following:

- A course covering statistical methods used in proficiency testing programmes following ISO 13528:2015¹ for Singapore Accreditation Council; Singapore Food Agency (SFA) and Biotransformation Innovation Platform — Agency for Science, Technology and Research (A*STAR)
- A dedicated workshop covering the requirements of organising proficiency testing programmes following ISO/IEC 17043² for SFA

^{1.} ISO 13528:2015 Statistical methods for use in proficiency testing by interlaboratory comparison ² ISO/IEC 17043:2010 Conformity assessment — General requirements for proficiency testing

LEVERAGING TECHNOLOGY

continually raise our efficiency standards.

DIGITALISATION IN THE LABORATORIES

After three years of hard work, we successfully digitalised most of our routine workflows and achieved a near paperless environment, with the launch of our new Labware Laboratory Information Management System (LIMS) in September 2020. The LIMS incorporates many digitalised workflows that enable data to move seamlessly across different sites and instruments, and the laboratories also utilise Robotic Process Automation (RPA) to replace some of the tasks which previously required human intervention.

- Some of the features include:
- Paperless submission/collection process for key stakeholders with system interface
- · Automatic interface of analysis requests and results, and despatch of e-reports
- Implementation of e-inventory for tracking of chemicals, reagents and drug reference standards
- Digitalisation of laboratory processes, such as electronically capturing the movement of exhibits (chain of custody), case assignment, review and reporting
- Configuration to trigger and automate actions at various decision points, which greatly reduces human transcription and interpretation errors



AUTOMATING VIDEO ANALYSIS FOR VEHICLE SPEED CALCULATIONS

We developed a Visual Basic for Applications (VBA) Excel macro to automate traffic accident reconstruction video speed calculations.

RISING TO THE

CHALLENGE

Through the thoughtful use of technology, we are able to



of our laboratories' workflows and processes have been digitalised



We have also received positive feedback from users and stakeholders that the system has helped to streamline their operational processes

Manually calculating vehicle speed used to be a tedious process that took

hour per video

Our new customised macro allows us to automatically extract data, perform calculations and plot graphs

in just minutes 70

BENCHMARKING OURSELVES

We maintain the highest standards of work by benchmarking to global standards.

PROFICIENCY TESTING AND INTERNATIONAL COMPARISONS

Over the year-in-review, we participated in various benchmarking programmes, achieving excellent results in the process.

Type of Benchmarking	Proficiency Testing (PT)	International Comparisons
Details	 Potentiometric determination of pH in ascorbic acid and sodium ascorbate Assay of Nitrofurazone, organised by European Directorate for the Quality of Medicines & HealthCare (EDQM) 	 Consultative Committee on Amount of Substance: Metrology in Chemistry and Biology (CCQM) key comparison on zearalenone in maize, organised by National Institute of Metrology, China (NIM)
	 Assay of Progesterone by UV spectrophotometry, organised by EDQM 	 CCQM key comparison on amino acid in human plasma, organised by LGC
	• Disintegration of tablet, organised by Laboratory of the Government Chemist (LGC), UK	 External Quality Assessment Scheme for Reference Laboratories in Laboratory Medicine (RELA)- International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) comparison on glycated haemoglobin (HbA1c)

ESTABLISHMENT OF **INTERNATIONAL CHEMICAL REFERENCE SUBSTANCES**

We participated in inter-laboratory collaborative studies, organised by EDQM, to establish the reference substances for Ivermectin and Amodiaquine Hydrochloride for WHO International Pharmacopoeia.

EXPANDING OUR CHEMICAL METROLOGY SERVICES

We are always on the lookout to expand our metrology services, and routinely add new substances to our testing capabilities.

OUR CERTIFIED REFERENCE MATERIALS (CRM) LIST HAS BEEN EXPANDED TO INCLUDE:

August 2020 Inorganic Elements (As, Cd, Pb) in Herbal Material



September 2020 Pure substance 4-cumylphenol

OUR ACCURACY-BASED PROFICIENCY TESTING/EXTERNAL QUALITY ASSESSMENT PROGRAMMES HAVE BEEN EXPANDED TO COVER:

- Total protein in human serum for clinical laboratories in Singapore



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November 2020 Pure substance sibutramine hydrochloride monohydrate

• Aflatoxins in plant-based food material for food testing laboratories (seven participating laboratories in Singapore) • Trace elements (arsenic, antimony, barium, cadmium, lead, manganese and selenium) in drinking water for water testing laboratories (20 participating laboratories across Singapore, Myanmar and Chinese Taipei)

INTERNATIONAL COLLABORATIONS

RISING TO THE

CHALLENGE

We continued to collaborate with the international community by offering our expertise and through knowledge sharing.

GOVERNMENT LABORATORY OF HONG KONG (HKGL) ACCREDITATION ASSESSMENT

In January 2021, we were invited by the Hong Kong Accreditation Service (HKAS) to conduct a remote assessment for HKGL in the examination of questioned documents. This is the second time in two years that we have been invited to be the technical expert in conducting assessments using the ISO/IEC 17025:2017 standard.









GLASS INTERPRETATION INTER-LABORATORY STUDIES

Over the past few years we have been involved in interlaboratory glass tests organised by Dr Jose Almirall from Florida International University to evaluate the interpretation of glass refractive index measurements.

In our latest project with Dr Almirall's team, together with seven other international laboratories, we served as reference laboratories in a study to determine the concentrations of trace elements in new float glass standards. The results of this study will contribute towards creating new commercially-available glass calibration standards for the Laser Ablation Inductively-Coupled-Plasma Mass Spectrometry (LA-ICP-MS) application.

AGREEMENTS AND MEMORANDUM

Over the past year, we inked and renewed the following agreements:

Agreements

Purity assessment of therapeutic proteins

Commutability study on small molecules and/or protein diagnostic markers in human biological fluids

To support the national standards and conformance infrastructure, and strengthen the dissemination of metrological traceability to local laboratories

Cooperative research on the development of novel techniques and methods for the detection of SARS-CoV-2

OUR COLLABORATIONS WITH WHO

We continued to actively support WHO as a collaborating centre through the following activities:

Drug Quality Assurance

Monograph development work for the international pharmacopoeia

We partnered WHO in the monograph development of Ulipristal Acetate and Ulipristal Acetate tablets for the International Pharmacopoeia.

Event

WHO consultation meet on quality control and specifications for medicines

WHO Regional Meeting (WPRO)

55th Expert Committee on Specifications for Pharmaceutical Preparations

WHO Forum on "From Containment to Suppression — COVID-19 Lessons"

Partner(s)
National University Health System (NUHS)
Enterprise Singapore through Singapore Accreditation Council
National Institute of Metrology, China

	Date
aboratory tools	May 2020
	August 2020
	October 2020
	December 2020

Tobacco Testing and Research

Lead author for first horizon paper

We are the lead author of the first horizon paper titled, "Nicotine forms in tobacco plant, chemical modifications and implications for electronic nicotine delivery system". The paper is jointly authored with the American University of Beirut, Lebanon.

Establishment of standard operating procedures (SOPs)

We collaborated with WHO and EU Joint Action on Tobacco Control to establish SOPs in the determination of nicotine, glycerol and propylene glycol in e-liquid.

Webinar series on tobacco product regulation

HSA's Dr Cheah Nuan Ping was invited in her capacity as Chair of the Tobacco Laboratory Network to present six chapters from the WHO handbook for a webinar series.

The objective of the webinar titled "Building laboratory testing capacity" is to advance tobacco regulation in WHO member states and improve their understanding of testing-related activities.

In just the first week alone, more than



product regulation

We led a total of



laboratories to establish

for measuring nicotine content in smokeless tobacco products

Tobacco-related events

Event	Details	Date	
Virtual workshop organised by Ministry of Health, Family and Welfare of the Government of India	We conducted a "Research Methodology Workshop" to encourage and stimulate interest in tobacco research in India	May 2020	
Tobacco testing training for scientists and technical personnel from Noida, Mumbai, Guwaharti and Bangalore, India	We conducted a series of tobacco analysis training workshops	June 2020	
WHO's 148 th Executive Board Meeting	Singapore's contributions in the area of tobacco product regulation was shared	January 2021	





BUILDING AND SHARING OUR KNOWLEDGE

ASEAN Pharmaceutical Testing Laboratory Committee (APTLC) meeting

APTLC is a newly formed committee, which aims to strengthen ASEAN's capability in pharmaceutical testing.

In October 2020, we attended the APTLC virtual meeting, which saw the terms of reference and the development of the work programme for the next few years being discussed and finalised. At this meeting, Singapore was appointed as Vice-Chair to support the current Chair — Indonesia.

ASEAN Reference Substances Project

HSA continued its active involvement in the ASEAN Reference Substance Project, which aims to establish ASEAN secondary drug reference standards for use in ASEAN member countries.

Highlights of this past year include leading and working with five other countries to establish and study Hydroxyzine Hydrochloride as an ASEAN Reference Substance (PARS), and participating in the Thailand-led inter-laboratory study of Amoxicillin Trihydrate PARS.

ACTLC comparison study

We continued to contribute proactively to the ASEAN Cosmetics Testing Laboratory Committee (ACTLC), through a comparison study on "Determination of 1,4 dioxane in cosmetic products". This study was done in collaboration with ASEAN member states and Korea's Ministry of Food and Drug Safety.

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18th Western Pacific Regional Forum for the Harmonization of Herbal Medicines (FHH)

In February 2021, we were invited to attend the 18th Standing Committee Meeting of the Western Pacific Regional Forum for the Harmonization of Herbal Medicines.

The meeting and symposium, which was organised virtually by the National Institute of Food and Drug Safety Evaluation of Korea, provided a very good platform for networking and exchanging of information on the regulation of Chinese proprietary medicines, pre- and post-market activities, and risk management strategies for traditional Chinese medicine safety, as well as the development of test methods for herbal drugs.

South East Asia Tobacco Control Alliance (SEATCA) webinar

We were invited to speak at the following webinars organised by SEATCA:

Торіс	Date
Protecting Youth from New Tobacco Products Webinar — "Are electronic nicotine delivery systems and heated tobacco products really less harmful?"	June 2020
Tobacco Industry Monitoring Network Webinar — "Electronic smoking devices: Countering front groups and responding to misleading information."	November 2020

AWARDS AND ACCREDITATIONS

RISING TO THE

CHALLENGE

Our awards and accreditations serve to recognise and affirm our efforts that we are moving forward in the right direction.

ISO/IEC 17025 ASSESSMENT

As of March 2021, we have expanded our scope of accreditation to include the Determination of Nicotine in tobacco products by GC-FID, and are now fully compliant with ISO17025:2017.





We were honoured to receive the MHA Operational Excellence (OE) Award for our contribution towards uncovering a chemical lacing laboratory during Operation HOVOD in July 2019. This is the third consecutive year that we have been recognised for our partnership efforts to support MHA in shutting down clandestine laboratories.

DIGITAL & VIDEO/IMAGING TECHNOLOGY AND ANALYSIS (DVITA) ACCREDITATION

As evidence submissions for traffic accident and crime scene reconstruction cases become increasingly digital in nature, we recognise the need for knowledge gaps to be filled. To improve our competency, we have accepted unconventional cases, published a paper on estimating distances in speed analysis videos, participated in international digital evidence training, and joined an overseas digital forensics network.

In preparation for accreditation, our team also reviewed international best practices, validated methods and developed SOPs, while at the same time streamlining processes with automation and programmatic scripting.

All of these collective efforts have paid off with HSA being accredited in the area of DVITA at the ANSI National Accreditation Board audit.

