

Drugs in Aviation - A Review

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Abstract

The Aviation Medicine Department of the South African Civil Aviation Authority (SACAA), Aviation Medical Examiners (AME), and Institute for Aviation Medicine (IAM) receive numerous inquiries regarding the use of medication in the aviation environment. Flying an aircraft or controlling aircraft on the ground are highly demanding cognitive and psychomotor tasks, performed in an often inhospitable environment, with exposure to various sources of stress. It is therefore important for aviation personnel (i.e. aviation medical examiners, pilots, cabin crew and air traffic services personnel) to consider the effects that medicine or drugs may have on performance. Studies confirm that some pilots, and other crew members while on duty, used prohibited medications or illegal substances or performed duties while suffering significant unreported medical conditions. When considering aircraft mishaps and their causes, we tend to focus on the pilot. After all, he's in the driver's seat, there to troubleshoot any problems that may arise, and he's expected to bring the "on-loan" aircraft back to base, in one piece, after a mission. If a mishap occurs, investigators look for causes related to pilot error along with evidence of mechanical failure, weather factors, and runway condition and air traffic control (ATC) issues. Reviews of data from general aviation, commercial and military aircraft mishaps show that the two most often cited causal issues are pilot error and mechanical/logistical factors. If pilot error was identified, the ques-

tion now arises: Are some instances of incorrect controlling of an aircraft due to human factors, such as poor diet or insufficient rest (self-imposed), fatigue, poor concentration, shift-work problems, inadequate training or lack of motivation?

More specifically, the following in terms of pilot error have been identified in the USA:

- Flying under the influence of alcohol – 15%
- Conducting unwarranted manoeuvres – 30%
- Penetrating known adverse weather conditions beyond pilot and aircraft capabilities – 40%
- Drug impairment of the pilot (includes prescribed medication) – 6%
- Miscellaneous – 9%

Although these statistics relate to the pilot, they can no doubt be extended to other aviation personnel e.g. ATC, cabin crew (CC) and aircraft maintenance officers (AMO). Of note is that up to 6% of aircrew are 'under the influence of medication' while operating an aircraft. Aircrew, like all of us, are prone to illness, but those who take medicine on an inadequately informed basis or undertake self-medication, not only endanger their lives but also jeopardise the safety of passengers and costly aircraft.

The Aviation Medicine Department of the South African Civil Aviation Authority, Aviation Medical Examiners, and the Institute for Aviation Medicine receive numerous inquiries regarding the use of medication in the aviation environment. In addition, reports have been received relating to aviation personnel using unapproved medication or illegal drugs. Furthermore, a physician may prescribe

medication for a patient while being unaware that the patient is performing duties within the aviation environment. Or, a pilot self-medicates because consulting an AME may result in flying privileges being withdrawn.

Flying an aircraft or controlling aircraft on the ground are highly demanding cognitive and psychomotor tasks, performed in an inhospitable environment, with exposure to various sources of stress. It is therefore important for aviation personnel (i.e. aviation medical examiners, pilots, cabin crew and air traffic controllers) and non-aviation medical examiners to consider the effect that medicine or drugs may have on aviation performance. A study performed in 1994 by the FAA revealed that an estimated 14 000 US pilots flew while using prohibited medications or illegal substances or flew with significant unreported medical conditions.¹

Greater understanding of the effects of medication in humans, and advances in drug development have now made possible the use of various medications by aircrew. In this context assessment of side effects which a drug may have on performance, has become an important part of its clinical profile and provides increased and more informed availability of potential therapy for aircrew.

The aim of this review is to make the non-aviation medical examiner aware of, and to provide an understanding of the issues involved rather than to provide recommendations for drug use in aviation and to outline the various approaches that can be adopted to assess whether a drug can be used safely.

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Aspects of drug mechanism

All medications (including inhaled gases) are chemical substances. Even relatively simple chemicals such as O₂, H₂O, N₂, CO₂, ozone etc can influence the chemistry or physiology of the body and even the effect of medication. Other factors that can influence the effect of a drug include.²

- Type and dosage of drug
- Chemistry and excretory mechanisms
- State of organ function
- Presence of other drugs
- Physiological status and environmental conditions
- Altitude and pressurisation etc

Depending on these factors the effect of the medication may be negligible, therapeutic, toxic, or lethal. The modern aircrew has to remain fit, physically and mentally, to handle sophisticated high-speed aircraft that demand split second decisions to avert incidents or accidents. Also, aircrews operate at an exceptional level of competence under hostile aviation conditions which include.³

- Hypobarism when at high altitude
- Hypoxia
- Hypothermia
- Vibration
- High G-forces
- Complex multi-axis movements
- Disturbed sleep patterns
- Fatigue
- Boredom interspersed with periods of intense concentration / sensory overload
- Turbulence
- Disorientation

The problem is that most drugs have not yet been tested under these conditions!

Other reasons why medication may pose a threat to aviation safety

- Although effects and side effects may be minor on the ground, they may be less predictable at altitude due to environmental factors such as hypoxia or gas expansion caused by decrease in air pressure.
- Possible side effects such as drowsiness, impairment of judgment, upset stomach and visual disturbance could cause an impairment that might lead to incapacitation while flying or controlling. It was found in 1998 in the USA that 48 pilots died through aviation accidents because of being under the influence of medication.⁴

- Interactions of medication with other drugs may impair performance ability or may even cause incapacitation. This may only become evident at altitude.
- An allergy to a specific medicine or components of a product may have severe consequences especially in the case of a delayed reaction.
- Individual factors such as fatigue and stress may exacerbate the wanted and unwanted effects of medication.
- Usually the underlying condition for which the person is being treated, is sufficient reason for the person not to fly.
- Does the underlying condition preclude flying?
- Is there an SACAA medical protocol for the condition?
- Is medication really essential?
- Is the medication allowed or may certain restrictions exist?
- Are there any side effects present after a trial period on the ground?
- Is the treating physician familiar with aviation medicine?

In Table I, flight duties in terms of medication use by aircrew as classified by the CAA, are summarised as follows⁵:

Medical Protocols

It is important for aviation personnel to be honest in disclosing medical status to a treating physician. Many protocols exist for various medical conditions, and if adhered to, flight duties may still be possible.

Examples of such medical protocols are²:

- Hypertension
- Certain cardiac conditions
- Asthma
- Diabetes
- Rheumatoid arthritis
- Various malignant conditions
- Immunodeficiency
- Ophthalmic conditions
- Middle ear conditions

However, should any uncertainty exist, it is the responsibility of the treating physician and patient to contact an AME, the Institute of Aviation Medicine or the Aviation Medicine Department of the CAA to confirm that a specific medica-

Prescribed medication

Medication is defined as any substance used in the diagnosis, prevention or treatment of illnesses or symptoms. Aviation personnel may only use medication that has been approved by the Civil Aviation Authority. The problem which exists and as mentioned before, is that a physician may prescribe medication to aviation personnel while being unaware of the fact that the patient is performing duties within the aviation environment. Alternatively, the physician may be aware of the patient's occupation, but may have insufficient knowledge of the additional factors to consider when prescribing medication for personnel working within the aviation environment i.e. the physician may not have received training pertaining to aviation medicine.

Therefore, before medication can be prescribed to aircrew, the physician must determine the following:

Table I: Flight duties in terms of medication use

Type 1	Flight duties allowed if the medication is taken sporadically or, with exception, routinely. (<i>Aspirin, paracetamol, vitamins</i>)
Type 2	Flight duties permitted with permission from a registered AME/flight surgeon or the IAM. (<i>Antibiotics, anti-malarials</i>)
Type 3	Flight duties permitted only with permission from IAM. Usually involves long term use. (<i>Allopurinol, propranolol, thyroid preparations</i>)
Type 4	Possible unacceptable side effects. Flight duties not permitted until medication adequately cleared from the body, usually at least 5 - 7 times the half-life of the medication. (<i>Barbiturates, steroids, codeine phosphate</i>)
Type 5	Flight duties not permitted due to underlying medical condition, or possibly the type of medication required. (<i>Anti-coagulants, nitrates, insulin, oral hypoglycaemic, digoxin</i>)
Type 6	Frequently occurring unacceptable dangerous side effects in relation to flight duties. Flight duties not permitted until medication totally cleared from the body – usually 5 - 7 times the elimination half-life ($t_{1/2B}$) of the medication. (<i>Anti-convulsants, anxiolytics, alcohol, stimulants</i>)
Type 7	Completely illegal substances. (<i>Dagga, LSD, cocaine, heroin, "Ecstasy", etc</i>)

tion has been approved for use in the aviation environment.

Self-medication

Self-medication or over-the-counter medications (OTCs), especially in terms of aviation, is one of the curses of modern civilization. There can be many reasons for self-medicating:

- Increased knowledge of uses of common drugs through various media e.g. newspapers, magazines, television, radio and cinema etc.
- Easy availability of drugs: Many of the medicines not allowed for use by aircrew, can be bought at pharmacies without a doctor's prescription e.g. sympathomimetics, anticholinergics. Other drugs, e.g. aspirin, can be purchased at most supermarkets and even on the streets. Some aircrew may purchase these for use in common illnesses and ailments, especially when away from home, without consulting a physician.
- Lack of education: There is a lack of knowledge amongst aircrew regarding the hazards of self-medication.
- Costlier medical treatment: There is no doubt that specialisation and super specialisation in various branches of medicine have resulted in increased cost of treatment. An average citizen with limited resources cannot afford the best treatment. Patients often find the services of the general practitioner inadequate.
- Fear amongst aircrew for AME's: Aircrews are conscious of the fact that reporting to an AME for minor illnesses may result in stoppage of flying. This possibility may cause a phobia or fear complex so that they avoid the AME for anything concerning their health.

Dangers of self-medication

Due to the ready availability of these drugs, a perception exists that they are not dangerous – this is a wrong perception. The dangers of self-medication are many and can be summarised as follows:

- The symptoms may be a precursor of a serious illness that could lead to physical harm if left undiagnosed and inadequately treated. Temporary relief of symptoms like headache, throat pain, coughs, fever etc by self-medication may lead to false security and relief. Drugs taken in this way by an individual without a doctor's

Table II: Side effects of commonly used over-the-counter medication

Symptom	Medication	Side effects
Pain/fever	Aspirin	Ringing in ears Nausea Hyperventilation Stomach ulceration
	Anti-inflammatories	Dizziness Upset stomach
Colds/flu	Antihistamines	Sedation Dizziness Impaired coordination Blurred vision Thickening of bronchial secretions
	Decongestants	Dizziness Palpitations
	Cough suppressants	Drowsiness Blurred vision Upset stomach
Bowel preparations	Laxatives	Unexpected bowel activity at altitude
	Anti-diarrhoeal agents	Drowsiness Blurred vision
Appetite suppressants		Dizziness Palpitations Headaches
Stimulants	Caffeine	Tremors Palpitations Headache

Table III: Principles of unwanted drug effects

Predictable side effects	Unwanted pharmacological effects are likely to arise even when normal doses are given e.g. blurring of vision and dryness of mouth when using anticholinergics or older generation antihistamines.
Overdose	Unwanted results from exaggeration of drugs' desired pharmacological effect e.g. excessive drowsiness from tranquillisers, antidepressants and hypnotics even if taken only occasionally.
Hypersensitive reaction	Specific allergic sensitivity to certain drugs, e.g. penicillin, causes hypersensitive reaction. These range from mild reaction in the form of fever and rash to severe reaction leading to asthma and circulatory collapse and may only present during active flight duty.
Toxic effects and individual idiosyncrasy	Undesired results of drug administration in normal doses that may occur in some individuals and not in others, e.g. haemocytopenia from chloramphenicol and jaundice from chlorpromazine etc.
Drug combination effects	Potential of a drug by another e.g. hypokalaemia from thiazide and loop diuretics increasing digitalis effects, and alcohol increasing the effects of various hypnotics.
Inadequate elimination	Drug effect may be increased following normal doses where the means of elimination of that drug is inadequate, e.g. decreased hepatic metabolism in liver disease and decreased excretion in renal disease.

- prescription may be inappropriate, insufficient or ineffective.
- Over-dosage of a drug may produce side effects or toxicity resulting in fresh problems. Aircrew undertaking flying after self-medication could endanger themselves in flight because of possible aggravation of symptoms of illness and worsening the side effects of drugs.

Table II outlines the general side effects of commonly used over-the-counter medication.^{2,5}

As can be seen from Table II, most of these side effects would preclude the use of these drugs during aviation operational circumstances.

When an aviation personnel member considers using OTCs, it is important to

bring the following to their attention:

- Consider the possibility of a more serious underlying condition.
- Consider the advisability of flying or controlling when feeling so ill that they think they need medication.
- Recognise that many OTCs contain alcohol and/or antihistamines.
- Read the package insert and adhere to instructions.
- Recognise the therapeutic effects and side effects of the medication.
- It is inadvisable to fly after the initial dose.
- Rather contact the aviation medical examiner for advice.

Unwanted drug effects

It is helpful to consider unwanted drug effects under the headings as listed in Generally speaking, it is not possible to lay down hard and fast rules about drugs and flying as to do so would lead to many anomalies. However, certain clear cut principles must be recognised and these are that any drug or drug combination which may significantly impair judgment and performance and any drug or drug combination which may lead to sudden, serious and possibly catastrophic consequences are incompatible with any form of aircrew duties.

When an aircrew member considers using medication, the physician should make him/her aware of the following general guidelines:

- Aviation personnel, especially pilots, should be reminded that they are responsible for their own personal "pre-flight".
- Be wary of any illness that requires medicine to feel better.
- If an illness is serious enough to require medication, it is also serious enough to prevent him/her from flying or controlling an aircraft.
- When the aviation personnel member is not feeling well, the best action is to 'ground oneself' and wait to recover before resuming duties.

Furthermore, the CAA recommends three questions that an aviation crew member should consider before taking any medicine:

1. Am I really fit for duty?
2. Do I really need to take any medication at all?
3. Have I taken this particular medication as a personal trial on ground at least 24 hours before duty, to ensure that it will not have any adverse effects while on duty?

Table IV: Medication generally acceptable for use by aviation personnel

Anaesthetics	After a local anaesthetic, one day rest period.
Analgesics	Aspirin – anticoagulant in low doses, i.e. 81mg per day. Paracetamol – (short term). Not during flying.
Antibiotics	Most are acceptable. Illnesses for which antibiotics are prescribed, generally precludes flying. In certain chronic benign conditions, e.g. acne, where a long-term small dose antibiotic e.g. doxycycline (not minocycline) is used, is acceptable. Aminoglycosides are unacceptable. Macrolides may prolong Q-T interval.
Anti-inflammatories	As per NSAID protocol below.
Cardiovascular	<ul style="list-style-type: none"> • Cardioselective β-blockers: atenolol, acebutalol, etc. Not recommended for aerobatic/fighter pilots. • Hydrochlorothiazide with triamterene/amiloride. • ACE inhibitors (e.g. enalapril, perindapril). • Calcium channel blockers (e.g. nifedipine – excluding verapamil). • Cholesterol lowering substances: Fibrates, HMG Co-A inhibitors (e.g. atorvastatin). Cholestyramine is acceptable but not a drug of first choice. Probucol is not acceptable.
Dermatological	Topical antifungal, antiseptic, antibiotic, steroid, sunscreen, etc.
Diabetes: Type II	Metformin and acarbose.
GIT	<ul style="list-style-type: none"> • Simple antacids, sucralfate. • Peptic ulcers: Ranitidine as a nightly dose only, and no flying within 12 hours of the dose. Lansoprazole may be approved on an individual basis. Pilots may only fly if they are on maintenance therapy. • Kaolin preparations (for diarrhoea). • Simple bulk laxatives and lactulose (for constipation).
Gout	Allopurinol.
Hormones	<ul style="list-style-type: none"> • Low dose oral contraceptives after a 1 month stabilisation. • HRT (e.g. thyroid replacement, oestrogen). Requires a three-month stabilisation period. Prerequisite: Serum hormone levels must be normal on treatment. Other hormones and anti-hormones are generally not acceptable, and should be decided on an individual basis.
Hypnotics	Temazepam, zolpidem and zopiclone – 12 hrs before the next duty. Also, may lead to anterograde amnesia, therefore not to read critical documents after taking the hypnotic.
Malaria	Chloroquine and proguanil, doxycycline (excluding mefloquine and Halfan®).
Respiratory Tract	<ul style="list-style-type: none"> • Antihistamines – loratidine (Clarityne®, not Clarityne-D®), desloratidine, ebastine. • Sodium chromoglycate nasal spray, respiratory inhalers, and eye drops (e.g. Vividrin®). • Inhaled steroids (e.g. Inflammide®). • Steroid or decongestant nasal sprays (e.g. Beconase®, Iliadin® short term). • Carbocysteine. • Long acting β_2-stimulants – fenoterol, salmeterol. • Leukotrine antagonists = zafirlukast, montelukast. <p>No sympathomimetics e.g. pseudoephedrine.</p>
Steroids	Not permitted.
CNS	No tranquillisers, anti-depressants or psychotropics.
Vitamins	Vitamins, minerals, fatty acids but not in combination preparations containing stimulants or alcohol.
Others	Immunisation and desensitisation (may fly after 24 hours if no side effects or complications). Blood transfusion – not to fly within 24 hours of blood donation.

Often the nature of illness for which treatment is being given will preclude flying. It is probably not practical to say that aircrew should not under any circumstances take any medication, but the general principle is that no flying should be permitted during treatment with potentially hazardous drugs.

Medication generally acceptable for flight crew

Although it is best that aviation personnel should not go on duty under the "influence of medication", certain protocols and hence, certain medication, exists which are generally acceptable for use by aviation personnel. Table IV, gives a guideline of such medication.^{2,5}

Suggested protocol for the use of NSAIDs

Most CAAs permit their use if no untoward side effects exist and the specific condition does not preclude flying. Thorough questioning should exclude the following symptoms/effects if these drugs are to be used:

- Headache
- Vertigo, dizziness
- Nervousness
- Disorientation, convulsion
- Tremor, psychotic reactions
- Blurred vision, diplopia
- Impaired hearing, tinnitus
- Bronchospasm/dyspnoea
- Hypersensitivity

Disqualifying medications include the following groups:

- Anti-arrhythmics (amiodarone, etc)
- Antidepressants
- Anti-epileptic drugs
- Anti-glaucoma treatment
- Antihistamines (except as indicated earlier)
- Anti-migraine drugs (except sumatriptan; 24 hrs before flying)
- Anti-Parkinson drugs
- Anti-psychotics
- Anti-spasmodics (those with anticholinergic actions)
- Anti-vertigo (metoclopramide, cinnarizine, prochlorperazine)
- Anxiolytic drugs
- Asthma – no short-acting β_2 agonists, aminophyllin compounds, oral steroids
- Chemotherapy drugs/immunosuppressants (except as indicated earlier)
- CNS stimulants (methylphenidate)
- Diabetic treatment (insulin, sulphonylureas)
- Digoxin

- Hormone inhibitors
- Narcotic analgesics
- Steroids oral or parenteral
- Trophic hormones (except clomiphene)
- Warfarin (SACAA in process of setting up protocol)

To illustrate the point why a medication can compromise an aircrew, diclofenac, which is now commonly used, is discussed in terms of its potential side effects:

Nausea, vomiting, epigastric pain/abdominal cramps, diarrhoea/bloody diarrhoea, flatulence (altitude!), gastro-intestinal bleeding/gastric ulcer/perforation, headache, dizziness, vertigo, nervousness, tiredness, disturbed sensation, memory disturbance, disorientation, insomnia, irritability, convulsions, depression, anxiety, nightmares, tremor, psychotic reactions, blurred vision, diplopia, impaired hearing, tinnitus, urticaria, bronchospasm, palpitations, chest pain, anaphylaxis.

Of the 79 reactions, these are 32 reactions with possible acute effects in the cockpit.

Alternative and herbal medication

The use of herbal and other alternative medication has gained popularity and has become more readily available. There is also a belief being created that these medicines are "natural" and harmless. With virtual medicine being practised in cyberspace and the present "do-it-yourself" society, it is not surprising that the use of these drugs has escalated over the past few years. However, it is important to realise that problems do exist with the use of these drugs. The major problem is that the majority of these substances lack factual and objective study detailing their effects and side effects. Some of these drugs have potentially dangerous side effects e.g. ginseng's side effects include anxiety, irritability, nervousness and insomnia; St John's Wort can cause cataracts with long-term use.

Legal social drugs

Aviation personnel commonly use the so-called social drugs such as alcohol, caffeine and tobacco. In reality, all of these substances may pose a risk to aviation safety. It is essential for the aviation personnel member to remember that moderation is the key in the use of

socially accepted drugs.

Alcohol

Use of alcohol is legal, provided that it is done in moderation. The Civil Aviation Regulations require that aviation personnel may not:

- Consume any liquor less than 24 hours prior to reporting time for operational duty or the commencement of a shift.
- Commence an operational duty period while the concentration of alcohol in the blood is more than 0.0 gram per 100 milliliters.
- Consume alcohol during the operational duty period or whilst on standby for operational duty.
- Commence an operational duty period while under the influence of liquor or any drug having a narcotic effect.

A study conducted in the USA amongst pilots revealed that 50% of 2 200 respondents would fly within one hour of drinking, 16% of respondents admitted to drinking in excess, while 50% of respondents admitted to consistently underestimating the deleterious effects of acute alcohol use.⁴

The rate of absorption of alcohol is dependent on various factors such as the type and quantity of food in the stomach, body weight, hydration status, alcohol concentration, rate of consumption etc.

The immediate effects of alcohol use that may have an adverse effect on aviation safety include⁶:

- disorientation
- visual problems
- psychomotor dysfunction
- increased reaction time
- decreased short-term memory
- impaired thinking ability with decreased reasoning and decreased decision making abilities
- procedural errors in communications, navigation, manoeuvring, instrument landing (ILS) approaches

It is important to remember that the hangover effect may last for 48 to 72 hours following the use of alcohol. Symptoms commonly associated with a hangover are headache, dizziness, dry mouth, stuffy nose, fatigue, upset stomach, irritability, impaired judgment, and increased sensitivity to bright light. These effects may be compounded by other factors such as dehydration, fa-

tigue, nutrition and hypoxia associated with increased altitude.

Aviation personnel must apply the following principles when using alcohol:

- Compliance with the Civil Aviation Regulations.
- It is recommended to wait 24 hours from the last use of alcohol before performing duties or flying.
- Recognise that cold showers, black coffee or breathing 100% oxygen cannot speed up the elimination of alcohol from the body.
- Recognise that 12 hours from “bottle to throttle” does not mean that the blood alcohol concentration is below the legal limits or that no hangover effects will be experienced.

Caffeine

Long-haul pilots, in an effort to stay awake, regularly use coffee. The reason for this is that caffeine is a stimulant of the central nervous system leading to insomnia, a feeling of well being, excitability, but it may also result in irritability (especially in a multi-crew environment) and restlessness. It is a recognised fact that excessive coffee drinking can lead to irritation of the heart muscle which in

turn can lead to palpitations and changes on the ECG. Caffeine is also found in tea, Coke®, cocoa and chocolate.⁷

Tobacco


Nicotine is a highly addictive drug leading to cardiovascular, respiratory and cancerous diseases. In the aviation environment it may lead to hypoxia due to the affinity of carbon monoxide for haemoglobin in the red blood cells.⁷ Furthermore, nicotine withdrawal is also now recognised as a major contributing factor in air-rage.

Conclusion

Ideally an aircrew on duty should take no medication. When medication needs to be prescribed, it should only be done by a physician familiar with the unique challenges that the aviation environment present to the aviator and also how the use of medication may affect the ability of the pilot to aviate safely. Self-medication by aircrew should be discouraged and honesty in disclosure by the pilot encouraged (reporting culture). In this respect, the relationship between the aviator and physician will lead to good irmanship.

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See CPD Questionnaire, page 42

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