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Driver Health as a Road Safety Intervention: A Cross-Sectional Study of 2085 Occupational Drivers in Thailand

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Abstract

Road traffic injury remains a leading cause of preventable death globally, yet Thailand ranks among the world's highest road traffic mortality nations—without any systematic Medical Fitness to Drive (MFD) programme for licensed occupational drivers. This cross-sectional study examined 2085 public transport and for-hire drivers attending Thailand's first prototype MFD Clinic at the Institute for Urban Disease Control and Prevention, Bangkok (2020-2024), using a comprehensive six-domain assessment encompassing body composition, blood pressure, pulmonary function, vision, hearing, drug screening, sleep risk, and mental health. Findings revealed a substantial, multidimensional burden of safety-relevant conditions—each detectable through systematic screening, treatable through existing clinical pathways, and regulatable through the commercial driver licensing framework. OSA risk was identified in 44.5%, overweight or obesity in 59.6%, elevated blood pressure in 22.0%, chronic sleep insufficiency in 55.3%, and visual abnormalities in 19.6%. Depression was clinically identified in 4.9% of participants against a self-declaration rate of just 0.2%—a 25-fold disparity that illustrates why voluntary disclosure cannot substitute for structured assessment—and current suicide risk in 2.0%. Almost half (47.7%) reported a prior road crash history. None of these conditions is captured under Thailand's existing certification framework. The prototype program demonstrates operational feasibility through a tiered service delivery model, inter-ministerial governance architecture, and nationally contextualized clinical guidelines. It offers a replicable, evidence-based framework for low- and middle-income countries seeking to integrate systematic occupational driver health assessment into road safety policy—reframing MFD screening from a bureaucratic formality into a targeted public health intervention with quantifiable potential to prevent deaths at scale.

Keywords

Medical Fitness to Drive, Occupational Drivers, Road Safety, Obstructive Sleep Apnoea, Mental Health, Health Screening

1. Introduction

Road traffic injury remains a leading cause of preventable death worldwide, claiming approximately 1.19 million lives annually and disproportionately affecting LMICs, which account for more than 90% of road traffic deaths despite holding fewer than 60% of registered vehicles globally [1]. Thailand presents one of the most severe national profiles, with road traffic mortality rates of 32.7 per 100,000 population and nearly 940,000 crash incidents and 14,700 fatalities recorded in 2022 alone [2].

Driver health represents a distinct and frequently underappreciated determinant of crash risk. Epidemiological evidence demonstrates substantially elevated crash odds among drivers with specific medical comorbidities, including depression (8.75-fold), alcohol dependence (7.24-fold), epilepsy (5.92-fold), diabetes mellitus (4.49-fold), and cerebrovascular disease (3.50-fold) [3]. These risks operate through impaired reaction time, reduced visual acuity, microsleep episodes, and compromised executive function—all of which are potentially catastrophic in an occupational driver operating a multi-passenger vehicle.

MFD assessment is the structured clinical process by which a physician evaluates a driver's health status and functional capacity to determine fitness for vehicle operation, informing decisions on licence issuance, renewal, restriction, or revocation. High-income countries have embedded this process into licensing frameworks for decades: Australia's Austroads standards stratify medical criteria by vehicle class [4], and the United Kingdom's DVLA framework specifies fitness criteria across more than 200 conditions for commercial licence holders [5]. Evidence supports their effectiveness; mandatory vision screening for older drivers in Florida was associated with a 17% reduction in crash fatalities among drivers aged 80 years and above [6], while evidence from professional driver cohort studies indicates that pre-shift fatigue screening can substantially reduce crash incidence.

In contrast, Thailand's pre-existing framework was limited to a basic medical certificate excluding five legally prohibited conditions (leprosy, dangerous-stage tuberculosis, lymphatic filariasis, chronic alcoholism, and drug addiction), supplemented by fragmented performance tests administered separately by the Department of Land Transport—with no standardised referral pathways, no linkage between health and transport databases, and no periodic re-evaluation requirement for holders of lifetime licences issued under the Motor Vehicle Act (Amendment No. 12) B.E. 2546.

In response to this recognised gap and aligned with the WHO Global Plan for the Decade of Action for Road Safety 2021-2030 [7], the Department of Disease Control (DDC), Ministry of Public Health, in collaboration with the Department of Land Transport and the Road Safety Fund, established Thailand's first prototype MFD Clinic at the Institute for Urban Disease Control and Prevention (IUDC), Bangkok. This paper reports cross-sectional MFD assessment findings from this programme, with three objectives: 1) to quantify the prevalence and pattern of safety-relevant health conditions, risk behaviours, and mental health burden among Thai occupational drivers—establishing the epidemiological case for systematic MFD screening as a road safety intervention; 2) to describe the operational architecture of the prototype programme, including its tiered service delivery model, guideline development process, and inter-ministerial governance framework—demonstrating implementation feasibility within an LMIC public health infrastructure; and 3) to translate findings into an evidence-based policy framework, identifying specific regulatory, health system, and data infrastructure actions required to convert driver health screening from a prototype into an enforceable national road safety instrument.

2. Materials and Methods

2.1. Study Design and Setting

This cross-sectional descriptive study was conducted at the MFD Clinic, IUDC, Bangkok—Thailand's first government-operated MFD assessment centre. Two service modalities were employed: 1) clinic-based assessment, in which drivers self-presented; and 2) proactive workplace outreach, in which assessment teams deployed to transportation depots, intercity bus terminals, and taxi cooperatives. The outreach modality was adopted following observation of insufficient uptake under clinic-only provision, reflecting income-loss and scheduling barriers characteristic of this occupational group. Data were collected over the full operational lifespan of the programme (May 2020-March 2024), funded by the Road Safety Fund. The study is reported in accordance with the STROBE guidelines for cross-sectional studies [8].

2.2. Participants

Eligible participants held a current driving license for a public transport or for-hire vehicle issued by the Department of Land Transport, were aged ≥ 18 years, and provided written informed consent. No health-based exclusion criteria were applied, ensuring an unselected representation of the occupational driver population. A total of 2085 drivers with complete assessment records constituted the analytic sample; this exceeds the minimum of 1537 drivers calculated by the Krejcie and Morgan formula for a population of 10,000 (95% confidence; 2.5% precision). Drivers were classified into four vehicle categories: small for-hire vehicles (≤7 seats, including taxis), small public transport vehicles (songthaew), medium public transport vehicles (vans, ≤15 seats), and large public transport vehicles (buses and coaches, >15 seats).

2.3. MFD Assessment Protocol

2.3.1. Guideline Development

The MFD assessment guideline was developed by the DDC Injury Prevention Division in collaboration with nine Thai Royal Medical College specialty committees (neurology, cardiology, endocrinology, psychiatry, ophthalmology, otolaryngology, pulmonology, nephrology, and occupational medicine). It was adapted from the Austroads/National Transport Commission standards [4] and DVLA guidance [5], contextualised to reflect Thai diagnostic capacity, legal definitions, and operational feasibility for non-specialist clinicians. Eight disease domains were formalised: neurological disorders, cardiovascular disorders, diabetes mellitus, psychiatric disorders, substance misuse, visual disorders, renal and respiratory disorders, and miscellaneous conditions (including OSA, excessive daytime sleepiness, and medication effects).

2.3.2. Assessment Structure

The comprehensive assessment comprised six sequential parts. Part 1 captured driver and vehicle classification. Part 2 recorded sociodemographic data, driving history, self-reported chronic conditions, road crash history, and health behaviours. Part 3—the most extensive domain—covered anthropometry, blood pressure, complete blood count, urinary amphetamine screening, chest radiography, spirometry, comprehensive vision assessment (visual acuity, visual field, colour vision, dark adaptation, depth perception, and fundoscopy), audiometry, and upper-limb motor function, as well as structured OSA risk screening based on validated clinical history and anthropometric criteria (STOP-BANG criteria; snoring, felling tired, observed of OSA by other, high blood pressure, BMI ≥ 35 kg/m^2, Age ≥ 50, circumferential of neck 40 ≥ cm., Male gender, cut off score at 3 - 4 (moderate risk), 5 - 8 (high risk)). Part 4 comprised a standardised cognitive and psychomotor instrument assessing attention and reaction accuracy. Part 5 assessed safety attitudes and self-reported risk behaviours via a 20-item questionnaire. Part 6 administered the Thai-validated 9Q depression screening tool (scores 7 - 12 = mild; 13 - 18 = moderate; ≥19 = severe) and the 8Q suicide risk assessment instrument, with any positive response triggering immediate clinical referral.

2.3.3. Service Delivery Tiers

The operational model comprised three tiers to enable national scalability. Level A (Advanced) delivered the full protocol plus driving simulator assessment and polysomnography at a specialist centre. Level B (Basic) provided the standard clinic-based protocol excluding simulator and sleep study, operable by a traffic medicine physician and trained allied health officers. Level C (Common) offered a condensed outreach protocol deployable by a mobile team to transport workplaces, retaining history-taking, anthropometry, vision, hearing, haematology, drug screening, and mental health components while omitting radiography and spirometry.

2.4. Data Analysis

Data were analysed using descriptive statistics. Categorical variables are expressed as frequencies and percentages; continuous variables as means (SD) or medians (IQR) according to distributional characteristics. Records with physiologically implausible values—identified by pre-specified range checks—were excluded from analysis of the affected variable, resulting in slightly varying denominators reported in each table.

2.5. Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. All data were de-identified prior to research use. Written informed consent was obtained from all participants as part of the standard MFD clinical protocol. Data were managed in accordance with Thailand's Personal Data Protection Act B.E. 2562 (2019). The research was approved by IUDC EC 01/2024.

3. Results

3.1. Driver and Vehicle Characteristics

Of 2085 participants with complete vehicle data, the majority drove for-hire vehicles (n = 1253; 60.1%), with public transport vehicles accounting for the remainder (n = 832; 39.9%). Small vehicles (≤7 seats) predominated (n = 1475; 70.8%), followed by large vehicles (n = 492; 23.6%) and medium vehicles (n = 118; 5.7%). Most participants habitually drove short routes < 200 km (n = 1627; 78.1%) (**Table 1**).

Table 1. Driver and vehicle classification (n = 2085).

Characteristic	n	%
Vehicle type		
For-hire vehicle	1253	60.1
Public transport vehicle	832	39.9
Vehicle size by passenger capacity		
Small (≤7 seats)	1475	70.8
Medium (≤15 seats)	118	5.7
Large (>15 seats)	492	23.6
Usual driving distance		
Short (<200 km)	1627	78.1
Long (≥200 km)	458	21.9

Note: One participant had missing vehicle classification data and was excluded from this table only.

3.2. Personal Baseline Characteristics

The sample was predominantly male (n = 1830; 87.7%), with a mean age of 35.4 years (SD 14.1; median 31.5; range 18 - 84). Notably, 19.8% were aged over 60 years. Single marital status was most common (57.0%), followed by married or partnered (39.3%). Educational attainment was most frequently at the upper-secondary or vocational level (41.9%). Regarding driving experience, 46.2% had fewer than five years of commercial experience; 24.2% had more than 15 years. A self-reported chronic disease was declared by 19.4% (**Table 2**).

Table 2. Personal baseline characteristics (n = 2085).

Variable	n	%
Sex		
Male	1830	87.7
Female	255	12.3
Age group (years)		
18 - 39	1287	61.7
40 - 59	385	18.5
≥60	413	19.8
Mean age 35.4 ± 14.1 years (median 31.5; range 18 - 84)		
Marital status		
Single	1188	57.0
Married or partnered	819	39.3
Divorced or widowed	78	3.7
Educational attainment		
Upper-secondary/vocational certificate	874	41.9
Lower-secondary	443	21.2
Bachelor's degree or above	425	20.4
Primary school	303	14.5
Commercial driving experience		
<5 years	964	46.2
5 - 10 years	405	19.4
10 - 15 years	212	10.2
>15 years	504	24.2
Self-reported health status		
Reported ≥ 1 chronic disease	405	19.4

**Percentages may not sum to 100% due to missing data in some sub-categories.

3.3. Self-Reported Disease Prevalence

The most prevalent self-reported conditions relevant to driving safety were snoring (8.6%), cardiovascular disease (6.7%), and drowsiness or microsleep episodes while driving (5.8%)—a triad consistent with undiagnosed or untreated OSA. Diabetes mellitus was reported by 3.6% and asthma or chronic bronchitis by 2.4%. Critically, only 0.2% self-reported a psychiatric diagnosis—substantially lower than the screened prevalence identified in Section 3.6, indicating significant under-reporting of mental health conditions (Table 3).

Table 3. Self-reported prevalence of diseases and conditions relevant to driving safety (n = 2085).

Disease/Condition	n	%
Snoring	179	8.6
Cardiovascular disease	139	6.7
Drowsiness or microsleep while driving	122	5.8
Diabetes mellitus	75	3.6
Asthma or chronic bronchitis	50	2.4
Blood disorder	18	0.9
Respiratory tract infection	8	0.4
Kidney disease	6	0.3
Thyroid disease	6	0.3
Schizophrenia or depression (self-declared)	4	0.2

Note: Self-reported psychiatric diagnosis rate (0.2%) contrasts markedly with the screened depression prevalence of 4.9% identified by the 9Q instrument, underscoring the inadequacy of self-declaration for mental health ascertainment in this population.

3.4. Health Behaviours and Road Crash History

Nearly half of all participants were current smokers (46.1%), with a lifetime tobacco exposure rate of 54.0%. Habitual sleep of fewer than 7 hours per day was reported by 55.3%, and regular alcohol consumption (defined as ≥1 day/week) by 14.7%. Regular energy-drink use (≥4 times/month) was reported by 15.5%—a pattern consistent with a workforce managing chronic fatigue through stimulant behaviours. Almost half had experienced at least one road crash during their driving career (47.7%), of whom 17.2% had sustained injuries requiring hospitalisation (Table 4).

Table 4. Health behaviours and road crash history (n = 2086).

Behaviour/History	n	%
Tobacco use		
Current smoker	961	46.1

Continued

Former smoker	164	7.9
Never smoked	960	46.0
Alcohol and stimulant use		
Regular alcohol use (≥1 day/week)	307	14.7
Regular energy-drink use (≥4 times/month)	323	15.5
Sleep duration		
Sleep < 7 h/day	1154	55.3
Sleep ≥ 7 h/day	931	44.7
Surgical history		
Previous surgery	526	25.2
Road crash history (last 5 years)		
Any previous road crash	995	47.7
- Injury requiring hospital admission	358	17.2
- Injury not requiring admission	483	23.2
- Crash without personal injury	154	7.4

Note: Regular alcohol use defined as consumption on one or more days per week. Regular energy-drink use defined as four or more times per month. Sleep duration based on self-report of habitual daily sleep.

3.5. Physical Examination and Functional Capacity

Mean BMI was 24.8 kg/m^2 (SD 4.8). Using Asian-adapted WHO criteria, 59.6% were classified as overweight or obese (BMI ≥ 23 kg/m^2), including 41.0% with BMI ≥ 25 kg/m^2. Mean blood pressure was 124.3/69.9 mmHg (SD 19.1/13.9); elevated blood pressure (≥140/90 mmHg) was identified in 22.0% of participants (n = 439/2024 with complete BP data).

A positive OSA risk screen (loudly audible snoring by clinical history) was present in 44.5%. Composite OSA risk stratification classified 35.1% as moderate risk and 7.7% as high risk, with 57.2% at low risk. Abnormal vision findings were detected in 19.6% of participants, of whom 15.5% were already using visual aids. Abnormal complete blood count results represented the most prevalent laboratory finding (26.1%). Abnormal pulmonary function on spirometry was found in 2.9%, and abnormal chest radiograph findings in 2.6%. Hearing abnormalities were identified in 2.4%, and a positive urinary amphetamine screen in 0.8% (Table 5).

Table 5. Physical examination and functional capacity findings.

Examination/Finding	Result	%
Body composition		
Mean BMI (kg/m^2)	24.8 ± 4.8	-

Continued

Overweight or obese (BMI ≥ 23 kg/m^2)	1202	59.6
Obese (BMI ≥ 25 kg/m^2)	827	41.0
Cardiovascular		
Mean blood pressure (mmHg)	124.3/69.9	-
Elevated BP (≥140/90 mmHg) [n = 2085]	439	22.0
OSA risk screening		
Positive OSA risk screen (snoring)	902	44.5
OSA composite risk—low	1159	57.2
OSA composite risk—moderate	712	35.1
OSA composite risk—high	156	7.7
Vision		
Visual abnormality detected [n = 2085]	408	19.6
Currently using visual aids	324	15.5
Laboratory, imaging and other investigations		
Abnormal complete blood count	545	26.1
Abnormal pulmonary function (spirometry)	61	2.9
Abnormal chest radiograph	55	2.6
Hearing abnormality (audiometry)	51	2.4
Positive urinary amphetamine screen	16	0.8
Abnormal upper-limb muscle movement	3	0.1

Note: Denominators vary slightly across variables due to missing or physiologically implausible values excluded before analysis; valid n is stated where it differs materially from the total sample. OSA = obstructive sleep apnoea; BP = blood pressure; BMI = body mass index. OSA composite risk score incorporates snoring, witnessed apnoeas, hypertension, BMI > 35 kg/m^2, age > 50 years, neck circumference > 40 cm, and male sex.

3.6. Emotion, Concentration, and Mental Health Screening

Of 2026 participants completing the emotion and concentration test, 98.8% passed and 1.2% were referred for specialist neuropsychological evaluation. The general emotional-state screen flagged 10.5% as positive. Among 2027 completing the 9Q depression instrument, 4.9% met criteria for depression of at least mild severity (mild 3.1%; moderate 0.8%; severe 1.0%)—contrasting markedly with the 0.2% self-reported psychiatric diagnosis rate. Among 2028 completing the 8Q suicide risk instrument, 2.0% demonstrated current suicide risk (low 0.9%; moderate 0.2%; severe 0.8%). All 8Q-positive participants received immediate confidential clinical referral (Table 6).

Table 6. Emotion, concentration and mental health screening results.

Assessment/Finding	n	%
Emotion and concentration test (n = 2026)		
Passed	2002	98.8
Failed (referred for specialist evaluation)	24	1.2
General emotional-state screen (n = 2055)		
Positive (emotional dysregulation flagged)	216	10.5
Negative	1839	89.5
Depression screening—9Q instrument (n = 2027)		
No depression (score < 7)	1927	95.1
Depression—any severity	100	4.9
- Mild (score 7 - 12)	63	3.1
- Moderate (score 13 - 18)	17	0.8
- Severe (score ≥ 19)	20	1.0
Suicide risk assessment—8Q instrument (n = 2028)		
No current suicide risk	1988	98.0
Current suicide risk—any level	40	2.0
- Low risk	18	0.9
- Moderate risk	5	0.2
- Severe/imminent risk	17	0.8

Note: 9Q = Thai-validated 9-item depression screening questionnaire (equivalent of PHQ-9). 8Q = Thai 8-item suicide risk assessment instrument. All participants screening positive on the 8Q were referred for immediate confidential clinical review. Denominators reflect the number completing each instrument; not all 2086 participants completed every component.

4. Discussion

4.1. Driver Health as a Preventive Road Safety Intervention

This study presents the largest systematic MFD dataset reported from Thailand and, to the authors' knowledge, from Southeast Asia. Its central contribution is one of screening yield and burden estimation: systematic assessment detects, at scale, a convergent set of safety-relevant conditions that Thailand's existing certification model leaves largely uncaptured. Every condition identified in this cohort is detectable through systematic assessment, treatable through existing clinical pathways, and regulatable through the commercial driver licensing framework. The question is not whether such conditions exist in the driver population—this study confirms that they do, at scale—but whether the regulatory system is designed to find and act upon them. Under Thailand's existing certification model, it is not. This establishes the epidemiological rationale for MFD screening as a road safety intervention; it does not, and given the cross-sectional design cannot, demonstrate that screening itself reduces crashes. That effect is expected on the basis of the crash-risk associations and treatment evidence discussed below, but its confirmation requires prospective evaluation linking screening to subsequent crash outcomes.

The findings reveal a workforce carrying a convergent, multidimensional burden of conditions with direct mechanistic links to crash causation—conditions that remained undetected among drivers who had already satisfied every existing legal requirement for a commercial licence. This is not a failure of individual drivers; it is a structural failure of the regulatory framework designed to safeguard them and the travelling public. Reframing MFD assessment from a bureaucratic formality into a targeted public health intervention—with defined screening protocols, referral cascades, conditional licensing provisions, and real-time linkage to transport databases—positions it as a plausible crash prevention tool whose potential returns can be projected from existing evidence. Realising and measuring those returns, however, depends on downstream steps this dataset does not capture: effective treatment of screen-detected conditions, conditional licensing action, and longitudinal follow-up of crash outcomes.

4.2. Obstructive Sleep Apnoea: The Highest-Priority Actionable Risk

The OSA risk screen positivity rate of 44.5% represents the single largest, most clinically actionable, and most economically consequential safety risk identified in this cohort. This figure substantially exceeds general-population OSA prevalence: contemporary meta-analytic data place the pooled prevalence of sleep-disordered breathing in the general adult population well above the low single-digit estimates historically cited [9] [10], while driver-specific evidence shows a markedly higher burden still—pooled moderate-to-severe OSA prevalence reaches 37.3% in commercial drivers [11], with individual studies of Asian professional drivers reporting 28% - 78% [12]. That nearly half of an occupational driver population screened positive for OSA risk under a programme that did not previously exist underscores both the scale of the unmet clinical need and the detection value of systematic MFD assessment.

The public health significance derives from a well-characterised causal pathway. OSA produces intermittent nocturnal hypoxia and sleep fragmentation, generating excessive daytime sleepiness, impaired sustained attention, prolonged reaction times, and episodic microsleep—mechanisms directly implicated in crash causation. Meta-analytic evidence confirms that untreated OSA substantially elevates crash risk, with the mean crash-rate ratio among affected drivers estimated at approximately 1.2 to 4.9 relative to unaffected drivers [13]. The co-occurrence in this study of OSA screen positivity with self-reported microsleep while driving (5.8%), loud snoring (8.6%), and extreme obesity (BMI ≥ 35 kg/m^2 in 3.2%) defines a convergent, potentially synergistic risk profile of particular urgency in a workforce operating multi-passenger vehicles.

Critically, OSA is not only detectable—it is treatable. Continuous positive airway pressure (CPAP) therapy normalises crash risk among affected drivers to levels comparable to unaffected peers [14]. Despite this evidence, Thailand's current commercial driver medical certificate does not reference sleep-disordered breathing [15]—in stark contrast to the current American Academy of Sleep Medicine guidance recommending systematic OSA screening for commercial motor vehicle operators [16], and EU Directive 2006/126/EC, which requires documented treatment for OSA-positive Group 2 licence holders [17]. The Road Safety Fund's own economic modelling projects that systematic MFD screening—of which OSA detection is the highest-yield component—could prevent over 495 crash events annually, generating savings exceeding 1.1 billion baht per year [18]; these are modelled projections contingent on effective downstream treatment, not effects measured in the present cross-sectional sample. The case for OSA screening integration is therefore clinical, regulatory, and economic, and now warrants prospective confirmation.

4.3. Cardiovascular Risk: A Silent but Acute Threat

Elevated blood pressure in 22.0% of participants, combined with overweight or obesity in 59.6%, defines a workforce carrying substantial population-level cardiovascular risk. In the occupational driving context, however, the primary concern is not chronic morbidity but the risk of acute incapacitating events—sudden cardiac death, myocardial infarction, hypertensive crisis, or stroke—occurring during vehicle operation. A single such event in a fully loaded intercity coach or urban bus carries mass-casualty potential categorically different from the same event in a private vehicle, making cardiovascular fitness assessment a public safety imperative rather than a routine clinical formality.

The obesity prevalence in this sample (59.6% with BMI ≥ 23 kg/m^2; 41.0% with BMI ≥ 25 kg/m^2) meaningfully exceeds the Thai national average of approximately 37.5% [19], consistent with systematic reviews documenting elevated metabolic risk in occupational drivers attributable to sedentary work patterns, irregular meal timing, and circadian disruption [12]. Thailand currently lacks any structured cardiovascular fitness protocol for commercial drivers—no mandatory electrocardiography thresholds, no ejection fraction criteria, and no post-event driving cessation requirements—in contrast to the detailed cardiac standards specified by Austroads [4] and the DVLA [5]. Each of these conditions is identifiable at screening, manageable through primary care, and regulatable through defined licence conditions. Inaction is itself a policy choice—and in the occupational driving context, one with measurable safety consequences for drivers, passengers, and the public alike.

4.4. Visual Impairment: A Highly Modifiable Risk Factor

Visual abnormalities in 19.6% of participants—nearly one in five—identify vision as the third most prevalent safety-relevant finding in this cohort. Given that vision accounts for approximately 90% of driving-relevant information processing [20], the detection rate from this multi-component assessment was more than three times that implied by existing certification records—demonstrating that routine licensing vision tests administered by the Department of Land Transport are insufficiently sensitive to identify the clinically relevant deficits that systematic ophthalmic assessment detects.

Critically, vision impairment is among the most readily correctable conditions in this profile. The 15.5% of participants already using visual aids confirms both that the clinical pathway exists and that correction is culturally acceptable among this occupational group. The regulatory solution is correspondingly straightforward: mandatory periodic ophthalmic review integrated within a standardised MFD assessment cycle, linked to conditional licensing provisions for drivers with correctable or progressive conditions—precisely the model implemented under Australia's Austroads standard [4]. For Thailand's national MFD policy framework, vision screening integration represents the highest-yield, lowest-barrier regulatory enhancement available.

4.5. Chronic Sleep Insufficiency and Risk Behaviours: An Occupational Health System Failure

The finding that 55.3% of participants reported habitual sleep of fewer than 7 hours per day—compounded by regular energy-drink consumption in 15.5%—reflects a pattern of chronic occupational fatigue constituting a simultaneous road safety hazard, occupational health failure, and regulatory gap. The neurophysiological consequences are well-quantified: sustained wakefulness of 17 - 19 hours produces cognitive impairment equivalent to a blood alcohol concentration of 0.05 - 0.10 g/dL [21], and driving after fewer than 5 hours of sleep carries crash risk comparable to operating at the legal alcohol limit [22]. Meta-analytic evidence confirms that sleepiness and fatigue significantly elevate crash risk among professional drivers (pooled OR 1.34; 95% CI 1.25 - 1.43) [23], and systematic reviews of fatigue countermeasure interventions indicate that structured screening and management programmes can reduce drowsiness-related crash risk, though effect sizes vary by intervention type and setting [24].

Current smoking in 46.1% of participants—well above the Thai national adult male smoking prevalence of roughly 35% [25]—further compounds this risk profile through promotion of OSA, nocturnal hypoxic arousal, and subjective sleepiness masking, creating a potentially synergistic interaction with the fatigue burden documented above. Thailand's Road Transport Act B. E. 2522 [26] contains no provisions for mandatory minimum rest periods for for-hire and small public transport vehicle operators—the categories that predominate in this sample. This regulatory absence is not incidental; it is the direct legislative antecedent of the sleep insufficiency pattern documented here. Addressing it requires not only MFD screening but concurrent amendment of occupational driving-hours regulations across the full spectrum of commercial vehicle categories.

4.6. Mental Health: The Most Neglected Dimension of Driver Fitness

The detection of depression of any severity in 4.9% of participants and current suicide risk in 2.0%—against a self-reported psychiatric diagnosis rate of only 0.2%—represents the most policy-critical finding of this study. The 25-fold disparity between screened and self-declared prevalence reflects well-documented patterns of mental health under-reporting in occupational settings, particularly where psychiatric disclosure carries stigma and direct employment consequences [27]. Driver-specific evidence reinforces this concern: a recent systematic review of professional drivers reported depression prevalence ranging from 14.3% to 60.5%, far exceeding the 4% - 8% typically observed in corresponding general populations [28]. More fundamentally, it exposes the inadequacy of self-declaration as a mental health surveillance tool in the commercial driver certification context: a system that relies on voluntary disclosure to identify depression will, by design, fail to find it.

The road safety implications are severe. Depression impairs sustained attention, psychomotor reaction times, and risk perception, and is associated with an 8.75-fold increase in crash risk—the highest disease-specific crash risk multiplier reported in the epidemiological literature [3]. Extrapolating the 2.0% current suicide risk prevalence to Thailand's estimated 400,000 licensed commercial vehicle drivers implies approximately 8000 occupational drivers experiencing active suicidal ideation while operating passenger vehicles on any given day. This figure reframes mental health screening not as a clinical add-on to MFD assessment, but as simultaneously a road safety imperative and a humanitarian obligation.

The barriers to implementation are institutional, not technical. Validated, culturally adapted instruments already exist: the Thai 9Q depression screening tool and the 8Q suicide risk assessment instrument require fewer than five minutes to administer and minimal staff training. Confidential referral pathways—designed to protect drivers' employment status while connecting them to clinical support—actively reduce disclosure barriers. What is absent is not the tool, but the regulatory mandate to use it. Integration of validated mental health screening into all MFD protocols, with defined confidential referral cascades, represents one of the highest-yield and lowest-cost enhancements available to Thailand's commercial driver certification system.

4.7. Implementation Lessons: A Replicable Model for the Region

Beyond its epidemiological contribution, this study documents the operational feasibility of MFD programme implementation within a public health infrastructure characteristic of an upper-middle-income transitional economy. The programme's architecture—nationally contextualised clinical guidelines, inter-ministerial governance, tiered service delivery, and structured workforce training—aligns with the WHO Safe System Approach's emphasis on shared institutional responsibility and scalable design [7]. Four lessons are directly generalisable to

LMIC health systems seeking a precedent for occupational driver health screening.

Formal inter-ministerial governance is non-negotiable. The Memorandum of Understanding between the Ministry of Public Health and the Ministry of Transport created shared accountability, data-sharing legitimacy, and cross-sector recruitment channels that clinic-housed programmes cannot replicate. The critical outstanding gap—real-time data linkage between the MFD health record system and the Department of Land Transport's licence database—requires sustained political commitment and must be resolved before clinical findings can generate enforceable licensing decisions.

Guideline contextualisation is a prerequisite, not an option. Direct adoption of high-income country standards in LMIC settings consistently produces frameworks that are technically sound but operationally unimplementable. The engagement of nine Thai Royal Medical College specialty committees to adapt international criteria to Thailand's diagnostic capacity and legal context represents a critical and transferable process step rarely documented in the published MFD literature from LMICs.

Proactive workplace outreach is the primary delivery model. Clinic-only provision generated insufficient uptake, reflecting structural barriers—income loss, shift incompatibility, and geographic distance—that characterise this occupational group. Deployment of Level C mobile assessment teams to bus depots, taxi cooperatives, and transport terminals should be the default initial strategy, with clinic-based services reserved for confirmatory investigation and complex case management.

Workforce investment is the rate-limiting factor for national replication. Structured training across traffic medicine physicians and allied health professionals—building on the Thai Traffic Medicine Association's curriculum framework—created the human capital prerequisite for both programme operation and future scale-up, offering a model for LMICs seeking to develop MFD capacity without establishing standalone specialist infrastructure.

4.8. Policy Gap Analysis: From Evidence to Enforceable Action

The findings of this study, interpreted against Thailand's existing regulatory framework, define three tiers of policy action—regulatory, health system, and data infrastructure—each with distinct responsible agencies, implementation timelines, and measurable outcomes, presented systematically in **Table 7**.

At the regulatory level, legal formalisation is the foundational prerequisite. MFD findings cannot be linked to licensing decisions until the eight disease-domain criteria are enacted through the Medical Council of Thailand and promulgated in the Royal Gazette. Parallel amendment of the lifetime licence exemption under the Motor Vehicle Act B. E. 2546 and application of the Occupational Disease and Work Environment Control Act B.E. 2562 [29] [30] provide complementary legislative pathways.

Table 7. Tiered policy recommendations for integrating medical fitness-to-drive assessment into Thailand's road safety framework.

Priority	Recommendation	Lead Agency	Timeline
	Level 1: Regulatory and Legislative Action		
HIGH	Revise the legally disqualifying medical conditions for commercial driving to incorporate eight disease-domain MFD criteria; promulgate through the Medical Council of Thailand and Royal Gazette.	Medical Council/ DDC/ MOPH	Short
HIGH	Establish mandatory periodic MFD re-evaluation for all commercial driver licence categories, with reassessment intervals calibrated to driver age (annually ≥ 65 years; every 3 years 45 - 64 years) and vehicle class.	DLT/ MOPH/ MOT	Short
HIGH	Repeal or amend the lifetime licence exemption provision of the Motor Vehicle Act B.E. 2546 to require periodic health review for all commercial licence holders above a defined age threshold.	Parliament/ DLT/ MOT	Medium
MEDIUM	Leverage the Occupational Disease and Work Environment Control Act B.E. 2562 to mandate workplace-based health surveillance for transport sector employees, creating a parallel employer-based MFD pathway.	Ministry of Labour/ MOPH	Medium
	Level 2: Health System and Service Delivery		
HIGH	Scale up the tiered MFD service model nationally: Level A specialist centres (Regional Disease Control Offices), Level B district hospital clinics, and Level C mobile outreach teams deployed to transport workplaces.	DDC/ Regional Health Offices	Short
HIGH	Integrate OSA risk screening as a mandatory MFD component, with a defined cascade: clinical screening → confirmatory polysomnography → conditional licence restriction pending documented CPAP treatment response.	DDC/DLT/ Sleep Medicine	Short
HIGH	Embed validated mental health screening (Thai 9Q for depression; 8Q for suicide risk) into all MFD protocols with confidential referral pathways that protect drivers' employment status and actively encourage disclosure.	DDC/Dept of Mental Health	Short
MEDIUM	Develop structured workplace health promotion programmes targeting the most prevalent modifiable risk factors in this cohort: smoking cessation, weight management, blood pressure control, and sleep hygiene.	RSF/ Transport Employers	Medium

Continued

	Level 3: Data Infrastructure and Surveillance		
CRITICAL	Establish real-time bidirectional data linkage between the MOPH MFD health record system and the DLT driver licensing database—the infrastructure prerequisite for translating clinical findings into enforceable licensing decisions.	MOPH/ DLT/Digital Economy Ministry	Short
MEDIUM	Develop a national occupational driver health registry to support prospective cohort studies linking MFD findings to crash outcomes, and to evaluate programme impact on road traffic injury rates over time.	DDC/RSF/ Academic Partners	Long

MFD = medical fitness to drive; DDC = Department of Disease Control; DLT = Department of Land Transport; MOPH = Ministry of Public Health; MOT = Ministry of Transport; RSF = Road Safety Fund. Timeline: Short = 1 - 2 years; Medium = 3 - 5 years; Long = >5 years. (RSF = Road Safety Fund, CPAP = continuous positive airway pressure).

At the health system level, the tiered service model is ready for national scale-up through existing Regional Disease Control Office infrastructure without requiring new facility construction. The highest-priority clinical enhancements are integration of structured OSA screening cascades and confidential mental health referral pathways into all MFD protocols, given the prevalence and crash-risk magnitude of these conditions documented in this cohort.

At the data and surveillance level, real-time bidirectional linkage between the Ministry of Public Health's MFD health record system and the Department of Land Transport's licence database is the infrastructure prerequisite for converting clinical findings into enforceable licensing decisions. A national occupational driver health registry, linked prospectively to crash records, would enable rigorous evaluation of programme impact on road traffic injury rates—the definitive outcome measure for a programme framed as a road safety intervention.

4.9. Strengths and Limitations

This study's principal strengths include the largest systematic MFD sample reported from any LMIC setting (n = 2086); a multi-domain assessment protocol simultaneously evaluating physical, sensory, laboratory, functional, and mental health dimensions across six structured parts; the use of validated Thai-language instruments for depression (9Q) and suicide risk (8Q), ensuring cultural and linguistic appropriateness; a dual-modality service delivery design—combining clinic-based and workplace outreach assessment—that reduces the attendance bias limiting the generalisability of clinic-only studies; and the generation of an operationally documented, tiered service model directly informing national MFD policy development.

Limitations follow principally from the study design. The cross-sectional design supports estimation of screening yield and of the burden of safety-relevant conditions, but precludes causal inference: it can neither establish that these conditions caused the crashes recorded in participants' histories nor demonstrate that MFD screening reduces future crashes. The reported crash history (47.7%) is retrospective and self-reported and therefore indexes co-occurring burden rather than any preventive effect of the programme; demonstrating crash reduction would require a prospective design linking screening, treatment, and subsequent crash outcomes. Further limitations include restriction to the Bangkok Metropolitan Region, limiting generalisability to provincial, rural, and border-area driver populations where health profiles and occupational exposures may differ; volunteer participation introducing potential healthy-worker and self-selection biases that may underestimate the true burden of safety-relevant conditions; reliance on self-report for behavioural and health history data, subject to recall and social-desirability bias—most consequentially for mental health and substance use; absence of confirmatory diagnoses for screen-positive OSA and mental health findings, meaning that prevalence figures represent screen-positive rather than clinically confirmed burdens; absence of a general-population comparison group, precluding direct quantification of excess risk attributable to occupational driving; and the absence of systematic medication data, a meaningful gap given the 19.4% chronic disease prevalence implying substantial pharmacological use with potential implications for driving fitness in this cohort.

Notwithstanding these limitations, the study's large sample, comprehensive multi-domain protocol, dual-modality design, and policy-oriented analytical framework collectively support the robustness of the principal findings and their relevance to MFD programme development in Thailand and comparable LMIC settings.

5. Conclusions

Driver health is not a peripheral consideration in road safety policy—it is a primary intervention point. This study provides the first systematic, large-scale evidence from Thailand and Southeast Asia that a structured MFD assessment programme is operationally feasible, clinically informative, and policy-generative within an LMIC public health infrastructure.

Among 2086 licensed occupational drivers, a substantial burden of safety-relevant conditions was identified—OSA risk (44.5%), overweight or obesity (59.6%), elevated blood pressure (22.0%), chronic sleep insufficiency (55.3%), visual abnormalities (19.6%), depression (4.9%), and current suicide risk (2.0%). Each is detectable through systematic screening, treatable through existing clinical pathways, and regulatable through the licensing framework. Under international MFD standards, each would trigger mandatory clinical follow-up or specialist referral. Under Thailand's current system, none are routinely captured.

The prototype programme has established what conditions exist, how to detect them at scale, and what policy changes are required to make detection consequential. Three tiers of action are needed: enacting legally enforceable MFD criteria through the Royal Gazette, scaling the tiered service delivery model through Regional Disease Control infrastructure, and establishing real-time data linkage between health and transport systems. Economic modelling projects that systematic MFD screening could prevent over 495 crash events and generate savings exceeding 1.1 billion baht annually [18]; this is a modelled projection contingent on effective treatment and enforcement, and the crash-reduction benefit it assumes remains to be confirmed by prospective evaluation rather than demonstrated by the present cross-sectional data.

Approximately 1.19 million people die on the world's roads each year [1]. A preventable fraction involves occupational drivers whose health conditions were never systematically assessed. The evidence of burden, and of feasible and scalable detection, now exists; what remains is to act on it and to measure, prospectively, whether doing so prevents crashes. On the first of these, the policy response is overdue.

Policy Recommendations

On the basis of the findings reported in this study, and informed by the operational experience of the prototype programme and international MFD frameworks [4] [5] [7], the following evidence-based policy recommendations are directed at policymakers, health authorities, and transport regulators in Thailand and in comparable LMIC settings. Recommendations are organised across three action levels, with priority classifications (**Critical/High/Medium**) and indicative implementation timelines (Short: 1 - 2 years; Medium: 3 - 5 years; Long: >5 years).

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Author Contributions

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Suthat Chottanapund: Conceptualization; Methodology; Supervision; Project administration; Funding acquisition; Writing-review and editing.

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

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