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The Ready-To-Go Questionnaire predicts health outcomes during travel: a smartphone application-based analysis

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Abstract

Background: The Ready-To-Go (R2G) Questionnaire is a tool for rapid assessment of health risks for travel consultation. This study aims to assess the utility of the R2G Questionnaire in identifying high-risk travellers and predicting health events and behaviour during travel in the TOURIST2 prospective cohort.

Methods: TOURIST2 data were used to calculate the R2G medical and travel risk scores and categorize each participant based on their risk. The TOURIST2 study enrolled 1000 participants from Switzerland's largest travel clinics between 2017 and 2019. Participants completed daily smartphone application surveys before, during and after travel on health events and behaviours. We used regression models to analyse incidence of overall health events and of similar health events grouped into health domains (e.g. respiratory, gastrointestinal, accident/injury). Incidence rate ratios (IRR) are displayed with 95% confidence intervals (95% CI).

Results: R2G high-risk travellers experienced significantly greater incidence of health events compared to lower-risk travellers (IRR = 1.27, 95% CI: 1.22–1.33). Both the medical and travel scores showed significant positive associations with incidence of health events during travel (IRR = 1.11, 95% CI: 1.07–1.16; IRR = 1.07, 95% CI: 1.03–1.12, respectively), with significant increases in all health domains except skin disorders. Medical and travel risk scores were associated with different patterns in behaviour. Travellers with chronic health conditions accessed medical care during travel more often (IRR = 1.16, 95% CI: 1.03–1.31), had greater difficulty in carrying out planned activities (IRR = –0.04, 95% CI: –0.05, –0.02), and rated their travel experience lower (IRR = –0.04, 95% CI: –0.06, –0.02). Travellers with increased travel-related risks due to planned travel itinerary had more frequent animal contact (IRR = 1.09, 95% CI: 1.01–1.18) and accidents/injuries (IRR = 1.28, 95% CI: 1.15–1.44).

Conclusions: The R2G Questionnaire is a promising risk assessment tool that offers a timesaving and reliable means to identify high-risk travellers. Incorporated into travel medicine websites, it could serve as a pre-consultation triage to help travellers self-identify their risk level, direct them to the appropriate medical provider(s), and help practitioners in giving more tailored advice.

Key words: behaviour, high-risk traveller, mHealth, risk stratification, tourist, travel medicine, triage tool

Introduction

Despite the enormous surge in worldwide mobility over the last decades, much still remains unknown about how travel affects health and behaviour. The current increase in post-pandemic travel offers a key moment to reflect on how travel medicine consultations can be improved, as travellers seem to be more aware of health- and travel-related risks and want to take appropriate precautions in order to minimize the risk.[1] Travel medicine often relies on non-specific pre-travel advice based on destination and vaccine recommendations packed into a short consultation. An improved understanding of how individual traveller characteristics and plans predict health behaviour and outcomes during travel would allow practitioners to provide more personalized advice targeted to the needs of their clients.

In 2022, Gazzotti *et al*.[2] introduced a novel medical pre-travel risk stratification tool, the Ready-To-Go (R2G) Questionnaire. This self-assessment tool assigns individuals a travel risk estimate based on their planned itinerary (e.g. destination country, travel purpose) and their pre-travel health status (e.g. chronic diseases, medication). Previous efforts to predict high-risk travellers before travelling using questionnaires have been limited. One study focused on travellers' risk perception (TRiP) and another focused on the Domain-Specific Risk-Taking Scale (DOSPERT). Neither included medical conditions, planned activities or incidence of health events during travel in their analyses.[3,4] Furthermore, while pre-travel risk assessment forms are readily available to guide practitioners during the pre-travel consultation, they do not give information on individual travel risks.[5–7]

An estimate of a person's travel risk allows better identification of individual needs for pre-travel preparation, especially for those at high risk of adverse outcomes. The full spectrum of health risks faced by travellers is wide, ranging from infectious diseases to traffic accidents to exacerbations of existing chronic diseases.[8] Given the limited time frame of pre-travel consultations, it is challenging to adequately address all possible risks for every traveller. In the past, researchers have attempted to improve the quality of travel consultations by prioritizing vaccine recommendations, proposing decision aids and analysing traveller perception of vaccines.[9–11] Improving health communication by using evidence-based tools that prospectively identify high-risk travellers could help travel medicine practitioners give more targeted advice to travellers at high risk for specific health issues.[12]

While the R2G Questionnaire has already been validated in 100 travellers using criteria defined by an expert panel,[2] it is also important to evaluate its utility in predicting actual health behaviours and outcomes in travellers on a larger scale. To do so, we used the data of an existing prospective cohort study (TOURIST2) tracking 1000 travellers and their health and behaviour during their travel from Switzerland to Brazil, China, India, Peru, Tanzania and Thailand.[13,14] In this study, we aim to assess how well the R2G Questionnaire predicts actual traveller behaviour and health outcomes during their trips by calculating the R2G risk scores for TOURIST2 travellers. Specifically, we aim to (i) compare the overall incidence of health events for travellers in low-, moderate-, substantial- or high-risk, and (ii) determine which health behaviours and adverse health outcomes are predicted by the R2G risk scores.

Methods

This study uses data from the prospective cohort study TOURIST2, which used a smartphone application to collect data on health and behaviour of travellers.[13,14] The baseline and trip data from the TOURIST2 study were used to calculate the R2G scores for each study participant. Patterns in the incidence of health events and behaviours during travel were then examined.

TOURIST2 study design and data collection

The prospective cohort study TOURIST2 enrolled a total of 1000 travellers from the travel medicine clinics of Zurich and Basel (Switzerland). Participants were eligible for inclusion if they travelled to Brazil, China, India, Peru, Tanzania, or Thailand, could use a smartphone during their trips, planned a travel for ≤4 weeks between 2017 and 2019, and were aged 18 or older.[13,14] The selected destinations were the most frequently visited by travellers attending the mentioned travel clinics, ensuring a sufficient sample size. The study was restricted to those travelling 4 weeks or less to ensure comparability (long-term travellers are thought to have different risks) and feasibility (the likelihood of completing a smartphone app-based survey daily for months is thought to be low). Participants were asked to complete a pre-travel questionnaire that collected basic demographic, medical, travel and risk-taking information. Furthermore, they completed a daily electronic questionnaire about health events and behaviours 10 days before, during and for 14 days after their trip on a smartphone application. The daily electronic questionnaire captured data on 6 health event domains (accidents/injuries, body aches, gastrointestinal symptoms, mental health, respiratory/flu like symptoms and skin infections or rashes) and nine health behaviour domains (alcohol/drugs, animal contact, health care utilization, avoidance of mosquito bites, food consumption, transportation use, physical activity, medication use and compliance, and sexual behaviour). Additionally, travellers rated their ability to complete planned daily activities and their overall daily travel experience on a 5-point Likert scale. Every daily questionnaire was automatically geotagged at the time of completion using the Global Positioning System. In addition, geolocation was collected automatically by the application every 15 minutes. Participants self-reported each health event based on its subjective severity using a Likert sliding scale that ranged from 1 (mild) to 4 (severe). A moderate or severe health event was defined as one that was rated 3 or 4 by the participant.[13,14] All travellers received a standard pre-travel consultation prior to their trips. More information on the TOURIST2 study design and recruitment is described in detail elsewhere.[13,14]

R2G Questionnaire

The R2G Questionnaire is a medical triage tool developed to identify different levels of travel-related risk. It is designed to be completed in <5 minutes by any traveller prior to travel using basic information about the planned itinerary and health status. It was developed by travel medicine experts and validated with 100 travellers.[2] It consists of nine questions, with higher points assigned to 'riskier' answers. Six questions are used to calculate the medical risk score and three questions are used to calculate

Table 1. Definition of R2G risk categories and score cutoffs. The R2G risk categories were assigned according to the risk categories pre-defined by the developers of the tool.[2] The R2G medical and travel risk score groups were defined according to breakpoints observed in the TOURIST2 data. Conditions that contributed to a high-risk medical score include chronic medical conditions, medication intake, allergies, and age. Questions that contributed to a high-risk travel score include risky destinations, long travel duration and specific travel purposes (like volunteer work, visiting friends and relatives, and travelling to remote regions). Full explanation on how the R2G scores were calculated are shown in Appendix A1–A3[2]

R2G risk categories[2]	Definitions
Low-risk category	Medical and travel risk score each ≤10 points
Moderate-risk category	Medical risk score ≤ 20 and travel risk score of 15–50 points
Substantial-risk category	Medical risk score ≤ 20 and travel risk score of ≥55 points
High-risk category	Medical risk score ≥ 20 points
R2G medical risk score groups	
No risk	Medical risk score of 0
Low risk	Medical risk score of >0–20
Moderate risk	Medical risk score of >20–60
High risk	Medical risk score of >60
R2G travel risk score groups	
Low risk	Travel risk score of ≤100
Moderate risk	Travel risk score of >100–130
High risk	Travel risk score of >130–160
Very high risk	Travel risk score of >160

the travel risk score. Both scores together define the overall risk category for each traveller (Table 1). The medical risk score is based on pre-existing medical conditions, current medications, allergies, adverse reactions to previous vaccinations, pregnancy and breastfeeding, and age. The travel risk score is based on travel destination, travel duration and travel purpose.[2]

R2G scores calculation and R2G risk category assignment

The R2G scores were calculated for each participant that completed the TOURIST2 study.[2] We used the baseline TOURIST2 questionnaire to fill out most of the R2G questions; exceptions are described in Appendix B. After calculating the medical and travel risk score, each TOURIST2 participant was assigned to the respective pre-defined R2G risk category.[2] For analysing the medical and travel risk score separately, we divided them into four groups (Table 1).

Statistical analysis

Incidence rate (IR) of health events during travel were calculated overall and by health domain by dividing the number of events reported by the geotagged survey-days and multiplying by 1000, resulting in IRs per 1000 travel-days. A survey-day is defined as a day where a questionnaire was filled out. Sunburn events were common, and therefore only events that were rated 3 (moderate) or 4 (severe) were included as a health event. Incidence of behaviours during travel were calculated by summing up the daily number of specific health behaviours performed by each traveller and dividing by the number of geotagged survey-days, multiplying by 1000 to obtain IR per 1000 travel-days. Incidence rate ratios (IRR) and associated 95% confidence intervals (95% CI) were calculated to compare IRs at home versus during travel as well as between R2G categories. To assess the relationship between R2G scores and incidence of health events (overall and domain specific), negative binominal models with offset terms accounting for varying travel time were used. To assess the relationship between R2G scores and incidence of accidents/injuries, logistic regression models with dichotomized outcomes were applied, due to the relatively small number of accidents. To assess the relationship between R2G scores and the ability to complete planned activities or the overall daily travel experience, linear regression models were applied. The level of statistical significance was set at $P < 0.05$. Interquartile ranges (IQR) or 95% CI were calculated where applicable. Sensitivity analyses were performed. One for participants where it was not possible to answer the travel purpose question and one by omitting some R2G travel risk questions. All statistical analysis was performed using R Statistical Software (version 4.2.3).[15]

Ethical considerations

The prospective cohort TOURIST2 and subsequent analyses of the data were approved by the Ethics Commission of the Canton of Zurich, Switzerland (KEK-ZH-Nr. 2014-0470, BASEC-Nr. 2017-00412). The TOURIST2 study is registered with clinicaltrials.gov under the identifier NCT03262337.

Results

Study population

793 participants completed the TOURIST2 study. Participants were slightly more often women (432/793, 54.5%), young (median age: 34.0, IQR: 28.0–50.0), planned approximately 2-week trips (median trip days: 16.0, IQR: 14.0–23.0) and were mostly travelling for tourism (78.7%). Demographic characteristics of study participants are summarized in Table 2. Further TOURIST2 population characteristics are described in detail elsewhere.[13,14]

R2G scores were calculated for all 793 participants. According to the R2G categorization, 658 (83.0%) participants were considered to have a substantial risk for health events during travel and 135 (17.0%) a high risk. R2G high-risk category

Table 2. Baseline study population characteristics adopted from Farnham *et al.*[14] Participants are represented in more than one country, if they travelled to more than one country. 750 out of all 793 included participants also filled out daily questionnaires while at home in Switzerland

	Overall study	Brazil	China	India	Peru	Tanzania	Thailand	Switzerland (at home)
Number of travellers	793	183	35	145	95	225	135	750
Number of survey-days	19 341	2184	397	1917	1134	2353	1688	9668
Age	34.0 (28.0–50.0)	35.0 (29.0–50.0)	34.0 (31.5–48.5)	37.0 (28.0–53.0)	31.0 (26.0–41.5)	37.0 (28.0–51.0)	30.0 (25.0–37.5)	34.0 (27.0–50.0)
Female sex	432 (54.5%)	89 (48.6%)	15 (42.9%)	73 (50.3%)	57 (60.0%)	123 (54.7%)	84 (62.2%)	411 (54.8%)
Planned trip days	16.0 (14.0–23.0)	16.0 (14.0–23.0)	20.0 (15.0–29.0)	17.0 (13.0–24.0)	21.0 (16.5–27.0)	15.0 (12.0–19.0)	20.0 (15.0–29.0)	16.0 (14.0–23.0)
Reason for travel								
Tourism	624 (78.7%)	123 (67.2%)	32 (91.4%)	96 (66.2%)	82 (86.3%)	186 (82.7%)	124 (91.9%)	593 (79.1%)
Business	57 (7.2%)	24 (13.1%)	2 (5.7%)	14 (9.7%)	4 (4.2%)	14 (6.2%)	2 (1.5%)	49 (6.5%)
Volunteering	28 (3.5%)	1 (0.5%)	0	7 (4.8%)	4 (4.2%)	15 (6.7%)	3 (2.2%)	28 (3.7%)
Visiting friends and relatives	63 (7.9%)	1 (0.5%)	0	12 (8.3%)	4 (4.2%)	7 (3.1%)	0	59 (7.9%)
Missing	21 (2.6%)	2 (1.1%)	0	16 (11.0%)	1 (1.1%)	3 (1.3%)	0	21 (2.8%)
Medical score[a]	5.0 (0.0–5.0)	5.0 (0.0–10.0)	5.0 (0.0–15.0)	5.0 (0.0–10.0)	5.0 (0.0–15.0)	5.0 (0.0–10.0)	5.0 (0.0–10.0)	5.0 (0.0–10.0)
Travel score[a]	115 (95–130)	110 (100–125)	93 (75–110)	105 (95–115)	135 (115–145)	130 (120–140)	85 (70–95)	115 (95–130)
Participants considered to be high risk (R2G high risk category)[a, b]	135 (17.0%)	31 (17.3%)	7 (21.9%)	22 (15.2%)	17 (18.9%)	39 (17.6%)	19 (15.2%)	121 (17.5%)

[a] Here, if participants visited more than one country only the main destination (e.g. Tanzania) was considered. [b] Due to the fact that all the study countries included in the TOURIST2 study population were considered higher risk, no travellers fell into the low or moderate risk category.

travellers had a higher incidence of health events during travel (median IR = 1312, 95% CI: 1158–1722) per 1000 travel days than those in the substantial risk category (median IR = 1000, 95% CI: 909–1125) per 1000 travel days (IRR = 1.27, 95% CI: 1.22–1.33). This was driven mainly by an increase in gastrointestinal, respiratory and body ache symptoms (Figure 1). Travel purpose could not be answered for 8% of study participants ($n = 63$). Based on a sensitivity analysis, categorizing these travellers as 'other' travelling reason versus not assigning additional points (i.e. treating them as beach holiday travellers) did not yield a major difference in the IR and IRR (<0.1%). Therefore, the reason for travel for these participants was assigned as 'other'.

High-risk medical score participants

Overall, a medical risk score of 5.0 (IQR: 0.0–5.0) was calculated for the study population. 452 (57.0%) participants had a medical risk score above 0, indicating that they were travelling with a chronic condition. Participants with a medical risk score above zero were slightly more likely to be male (60.8% vs. 54.0%) and had more health events during travel (IR = 1167, 95% CI: 1000–1313 vs. 1000, 95% CI: 800–1125), but were approximately the same age as travellers without chronic conditions (aged 35 vs. 33 years). Participants with a moderate medical risk score (>0 but ≤60, $n = 438$, 55.2%) had similar travel patterns to those without chronic conditions. Participants with a high-risk medical risk score (>60, $n = 14$, 1.7%) tended to travel for longer periods of time (19.0 vs. 16.0 days), were more likely to be visiting friends and relatives (VFR) (21.4% vs. 7.8%), did less risky travel overall (travel risk score of 100 vs. 115), and were more likely to visit Brazil or China (see Table 3). The median incidence of health events during travel increased linearly with increasing medical risk score (Table 3).

In a negative binomial model controlling for age, sex, planned trip duration, destination, travel purpose and the travel risk score, the medical risk score was significantly associated with overall incidence of health events (IRR = 1.11, 95% CI: 1.07–1.16, Table 4), meaning there was a 11% increase in incidence of health events for every 10 points increase in medical risk score. In health domain-specific models, the medical risk score was also significantly associated with incidence of gastrointestinal symptoms (IRR = 1.13, 95% CI: 1.07–1.18), respiratory and flu-like symptoms (IRR = 1.14, 95% CI: 1.07–1.23), body aches (IRR = 1.14, 95% CI: 1.07–1.21) and mental health events (IRR = 1.11, 95% CI: 1.03–1.20). Not associated with the medical risk score were incidence of skin disorders (IRR = 1.06, 95% CI: 0.99–1.14) and occurrence of accidents/injuries (OR = 1.00, 95% CI: 0.90–1.10) (Appendix C1–C6).

As incidence of health events may normally be higher for medical risk travellers even at home, the IRR of health events during travel versus at home (before and after travel) in Switzerland was calculated. For travellers with a moderate or high medical risk score, the IR during travel was significantly higher for overall health events (IRR = 1.38, 95% CI: 1.30–1.45), gastrointestinal symptoms (IRR = 1.92, 95% CI: 1.69–2.19), respiratory/flu-like symptoms (IRR = 1.37, 95% CI: 1.23–1.52) and symptoms concerning the skin (IRR = 2.22, 95% CI: 1.90–2.60) compared to at home. However, the IR was lower during travel than

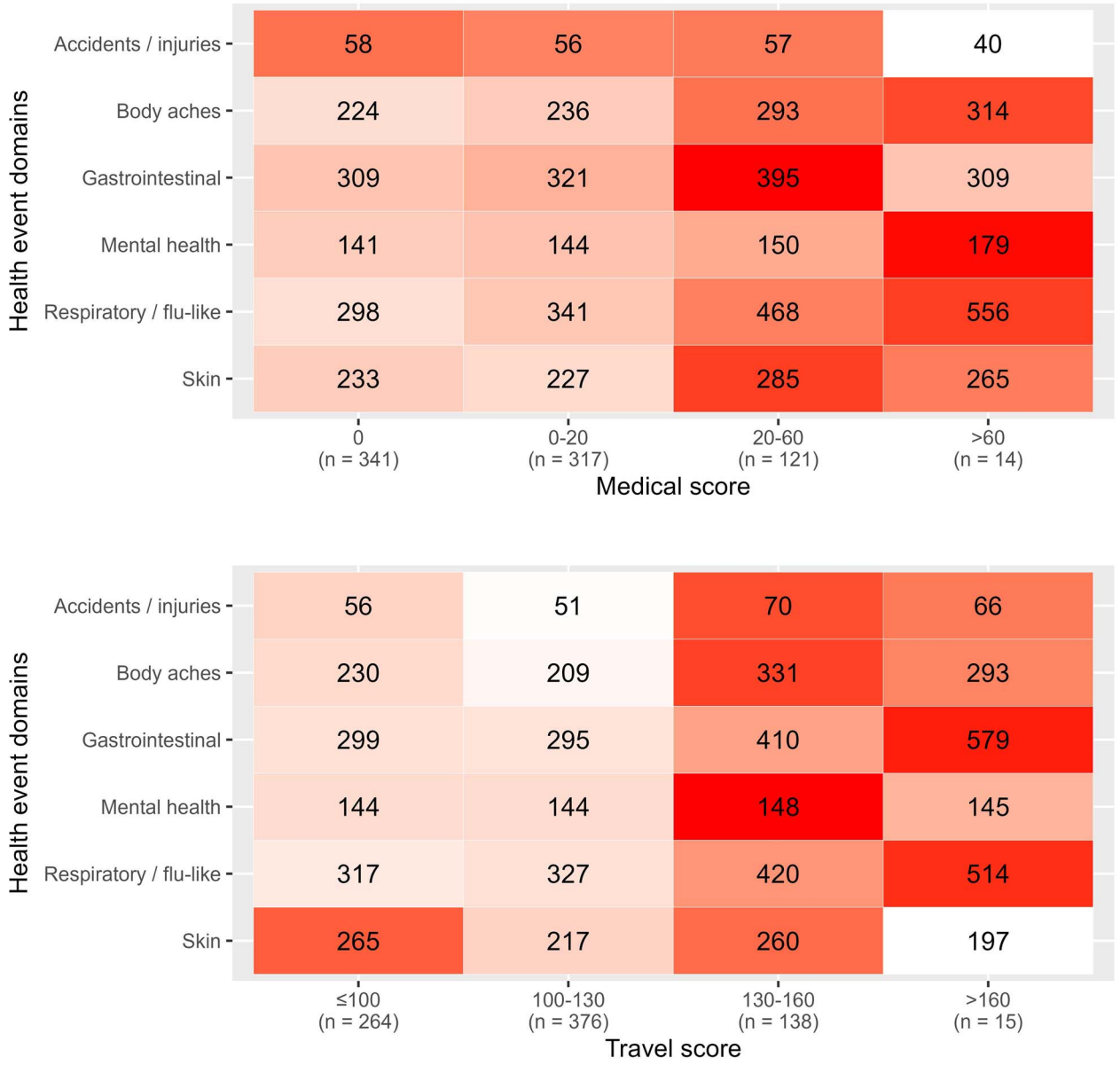

Figure 1. Heat maps showing IRs per 1000 travel days for each health event domain in different medical or travel score groups. Colouring is done per row.

at home for mental health events (IRR = 0.71, 95% CI: 0.61–0.83) and no significant difference was seen for accidents/injury (IRR = 1.28, 95% CI: 0.95–1.74) and body aches (IRR = 1.11, 95% CI: 0.98–1.26).

Higher medical risk scores were also significantly associated with certain health behaviours during travel compared to at home, including higher alcohol and illicit drug consumption (IRR = 1.09, 95% CI: 1.01–1.17), accessing medical care or needing medical help more often (IRR = 1.16, 95% CI: 1.03–1.31). They had a lower incidence of certain health behaviours, such as consuming risky foods (IRR = 0.97, 95% CI: 0.95–1.00). They also more frequently reported difficulty in carrying out planned activities (beta coefficient = −0.04, 95% CI: –0.05, −0.02), and the overall travel experience was worse (beta coefficient = −0.04, 95% CI: –0.06, −0.02) (Appendix C7–C14).

High-risk travel score participants

Overall, a travel risk score of 115 (IQR: 95–130) was calculated for the study population. 153 (19.3%) of participants had a high or very high travel risk score, indicating highly risky planned travel. Participants with a high or very high travel risk score were younger (aged 31 vs. 35 years), slightly more often women (58.2% vs. 53.6%), planned longer trips (19 vs. 16 days), and were more likely to travel for volunteering (11.1% vs. 1.9%) and less likely for business (3.9% vs. 8.1%) (Table 5). The median incidence of health events during travel increased linearly with increasing travel risk score (Table 5).

In a negative binomial model controlling for age, sex, planned trip duration, destination, travel purpose and the medical risk score, the travel risk score was significantly associated with overall incidence of health events (IRR = 1.07, 95%

Table 3. Characteristics of participants grouped according to medical risk score. A higher medical score indicated that they were travelling with chronic conditions (e.g. high blood pressure, asthma). B = Brazil, C = China, I = India, P = Peru, Ta = Tanzania, Th = Thailand, T = Tourism, B = Business, V = Volunteering, O = Other

Medical Score	No risk (0)	Low risk (0–20)	Moderate risk (20–60)	High risk (>60)	All
Participants	341 (43.0%)	317 (40.0%)	121 (15.3%)	14 (1.7%)	793 (100%)
% Women	157 (46.0%)	196 (61.8%)	71 (58.7%)	8 (57.1%)	432 (54.5%)
Age (median)	33.0 (27.0–47.0)	33.0 (27.0–50.0)	42.0 (29.0–55.0)	52.5 (30.3–67.0	34.0 (28.0–50.0)
Country visited	B = 77 (22.6%), C = 13 (3.8%), I = 55 (16.1%), P = 43 (12.6%), Ta = 104(30.5%), Th = 49 (14.4%)	B = 71 (22.4%), C = 12 (3.8%), I = 68 (21.5%), P = 30 (9.5%), Ta = 79 (24.9%), Th = 57 (18.0%)	B = 26 (21.5%), C = 5 (4.1%), I = 19 (15.7%), P = 16 (13.2%), Ta = 38 (31.4%), Th = 17 (14.0%)	B = 5 (35.7%), C = 2(14.3%), I = 3(21.4%), P = 1 (7.1%), Ta = 1 (7.1%), Th = 2 (14.3%)	B = 179 (22.6%), C = 32 (4.0%), I = 145 (18.3%), P = 90 (11.3%), Ta = 222(28.0%), Th = 125(15.8%)
Planned trip days (median)	16.0 (14.0–23.0)	16.0 (13.0–23.0)	16.0 (14.0–23.0)	19.0 (11.5–27.3)	16.0 (14.0–23.0)
Reason for travel	T = 279 (81.8%), B = 23 (6.7%), VFR = 23 (6.7%), V = 12 (3.5%), O = 4 (1.2%)	T = 240 (75.7%), B = 31 (9.5%), VFR = 25 (7.9%), V = 11 (3.5%), O = 10 (3.2%)	T = 96 (79.3%), B = 3 (2.5%), VFR = 13 (10.7%), V = 6 (5.0%), O = 3 (2.5%)	T = 9 (64.3%), B = 1 (7.1%), VFR = 3 (21.4%), V (0.0%), O = 1 (7.1%)	T = 624 (78.7%), B = 58 (7.3%), VFR = 64 (8.1%), V = 29 (3.7%), O = 18 (2.3%)
Median travel risk score (IQR)	115 (100–130)	115 (95–130)	115 (100–130)	100 (95–127.5)	115 (95–130)
Median IR of health events (95%CI)	1000 (800–1125)	1000 (909–1250)	1312 (1158-1727)	1479 (500–2500)	1036 (1000-1200)

Table 4. Negative binominal regression models showing the association between the R2G scores (predictor) and incidence of health events (outcome). Reference destination is Tanzania (the destination with the lowest incidence of health events) and reference purpose is tourism (the most common travel purpose).

Predictors	IRR (95% CI)	*P*-value
R2G Medical Risk Score	1.11 (1.07–1.16)	<0.001*
R2G Travel Risk Score	1.07 (1.03–1.12)	0.002*
Age	0.98 (0.97–0.98)	<0.001*
Sex (female = 1)	1.13 (1.00–1.28)	0.056
Planned trip duration	1.00 (0.99–1.00)	0.480
Destination Brazil	1.20 (0.98–1.47)	0.069
Destination China	1.73 (1.21–2.51)	0.003*
Destination India	1.58 (1.27–1.96)	<0.001*
Destination Peru	1.39 (1.12–1.72)	0.003*
Destination Thailand	1.47 (1.09–1.97)	0.009*
Travel Purpose: Business	0.91 (0.71–1.19)	0.490
Travel Purpose: Other	0.94 (0.54–1.79)	0.836
Travel Purpose: Study	1.47 (0.88–2.62)	0.161
Travel Purpose: VFR	0.91 (0.72–1.15)	0.419
Travel Purpose: Volunteer Work	0.76 (0.55–1.07)	0.106

Statistical significance as defined in the methods is shown with *.

CI: 1.03–1.12, Table 4). In health domain-specific negative binomial models, the travel risk score was also significantly associated with incidence of gastrointestinal symptoms (IRR = 1.07, 95% CI: 1.01–1.13), accidents and injuries (OR = 1.28, 95% CI: 1.15–1.44) and body aches (IRR = 1.13, 95% CI: 1.06–1.21). Not associated with the travel risk score were incidence of mental health disorders (IRR = 1.03, 95% CI: 0.95–1.12), respiratory and flu-like symptoms (IRR = 1.07, 95% CI: 0.99–1.16) and skin disorders (IRR = 1.05, 95% CI: 0.98–1.14) (Appendix C1–C6).

For travellers with a high or very high travel score, the IR during travel compared to at home was significantly higher for overall health events (IRR = 1.57, 95% CI: 1.49–1.66), accidents/injury (IRR = 1.94, 95% CI: 1.46–2.59), gastrointestinal symptoms (IRR = 2.05, 95% CI: 1.83–2.31), respiratory/flu-like symptoms (IRR = 1.53, 95% CI: 1.37–1.70), body aches (IRR = 1.22, 95% CI: 1.09–1.37) and symptoms concerning the skin (IRR = 3.07, 95% CI: 2.57–3.67). However, the IR was lower during travel than at home for mental health events (IRR = 0.84, 95% CI: 0.72–0.98).

Except for increased reporting of animal contacts (IRR = 1.09, 95% CI: 1.01–1.18), higher travel risk scores were not significantly associated with certain health behaviours during travel (Appendix C7–C14).

Table 5. Characteristics of participants grouped according to travel risk score. A higher score indicates that they planned more risks during travel (e.g. travelling to high mountain regions, backpacking). B = Brazil, C = China, I = India, P = Peru, Ta = Tanzania, Th = Thailand, T = Tourism, B = Business, V = Volunteering, O = Other

Travel Score	Low risk (0–100)	Moderate risk (100–130)	High risk (130–160)	Very high risk (>160)	all
Participants	264 (33.3%)	376 (47.4%)	138 (17.4%)	15 (1.9%)	793 (100%)
% Women	139 (52.7%)	204 (54.3%)	78 (56.5%)	11 (73.3%)	432 (54.5%)
Age (median)	34.0 (28.0–48.0)	37.0 (28.0–51.0)	31.0 (25.3–42.8)	30.0 (24.0–37.5)	34.0 (28.0–50.0)
Country visited	B = 53 (20.1%), C = 22 (8.3%), I = 69 (26.1%), P = 3 (1.1%), Ta = 0 (0.0%), Th = 117 (44.3%)	B = 109 (29.0%), C = 10 (2.7%), I = 67 (17.8%), P = 37 (9.8%), Ta = 145(38.6%), Th = 8 (2.1%)	B = 17 (12.3%), C = 0 (0.0%), I = 8 (5.8%), P = 44 (31.9%), Ta = 69 (50.0%), Th = 0 (0.0%)	B = 0 (0.0%), C = 0 (0.0%), I = 1 (6.7%), P = 6 (40.0%), Ta = 8 (53.3%), Th = 0 (0.0%)	B = 179 (22.6%), C = 32 (4.0%), I = 145 (18.3%), P = 90 (11.3%), Ta = 222(28.0%), Th = 125(15.8%)
Planned trip days (median)	16.0 (13.0–22.0)	16.0 (13.0–23.0)	19.0 (15.0–24.8)	23.0 (18.5–33.5)	16.0 (14.0–23.0)
Reason for travel	T = 214 (81.1%), B = 33 (12.5%), VFR = 7(2.7%), V = 1 (0.4%), O = 9 (3.4%)	T = 294 (78.2%), B = 19 (5.1%), VFR = 43(11.4%), V = 11 (2.9%), O = 9 (2.4%)	T = 108 (78.3%), B = 5 (3.6%), VFR = 14(10.1%), V = 11 (8.0%), O = 0 (0.0%)	T = 8 (53.3%), B = 1 (6.7%), VFR = 0(0.0%), V = 6 (40.0%), O = 0 (0.0%)	T = 624 (78.7%), B = 58 (7.3%), VFR = 64(8.1%), V = 29 (3.7%), O = 18 (2.3%)
Median medical risk score (IQR)	5.0 (0.0–10.0)	5.0 (0.0–15.0)	5.0 (0.0–10.0)	5.0 (0.0–5.0)	5.0 (0.0–5.0)
Median IR of health events (95%CI)	1000 (867–1222)	1000 (826–1111)	1372 (1125-1647)	1889 (950–2400)	1036 (1000-1200)

Discussion

This study used data from the TOURIST2 cohort to calculate the R2G scores for each study participant and to identify patterns in the incidence of health events and behaviours during travel. In our analysis, the R2G scores correlated with overall and health domain specific incidence of health events during travel, except for skin disorders. This indicates that the R2G questionnaire could serve as a tool for travel medicine practitioners to prospectively identify clients at high risk of adverse events during travel. Participants with high-risk medical scores (i.e. travellers with chronic diseases) also showed different patterns in behaviour during travel compared with both low-risk medical scores and those with high-risk travel scores. The descriptive characterization of high-risk travellers using the R2G Questionnaire is similar in most respects to known aspects of high-risk travellers, and matches that of previous studies, further confirming the validity of the R2G Questionnaire.[16,17]

High-risk medical scores

Those with chronic medical conditions and therefore a higher medical risk score had a significantly higher incidence of health events during travel than at home. Similar results were also reported by other studies,[18,19] but to our knowledge this is the first analysis that was able to show which types of health outcomes are specifically higher in travellers with medical conditions, and show that incidence of health events is higher than at home.[20–24] Increased incidence of health events was seen only for medical risk scores over 20 points, indicating that travellers with mild chronic illnesses are not necessarily at higher risk.[2] Medical risk travellers also accessed medical care more frequently, had increased difficulties in carrying out planned activities, and overall lower enjoyment of travel. While they did have more adverse mental health outcomes than other travellers, the incidence during travel was lower than at home for all groups, indicating that travelling can improve mental health. However, it is important to note that TOURIST2 was a cohort of relatively young travellers. Future studies should implement the R2G Questionnaire in older populations.

In our study, high-risk medical travellers were more likely to be VFR, who are known to have increased risk of health events during and after travelling.[25–27] Our findings suggest an association between chronic medical conditions and VFR, which could offer a partial explanation for this observed pattern. Moreover, it appears that individuals with chronic health conditions do not allow these conditions to dictate their choice of destination or activities, as reported by other studies.[28,29]

High-risk travel scores

Those with a high R2G travel risk score based on their planned itinerary showed distinct patterns in traveller characteristics and health outcomes and had a higher risk of adverse health outcomes during travel. These travellers were slightly more often women, had longer trips, and were volunteering more often. High risk travellers were also characterized by La Rocque et al to have longer trip durations.[17] Participants with a higher travel risk score also had more frequent animal contact during travel. An association between animal contact and health events during travel was also reported by Muehlenbein *et al*.[30] Further, the fact that accidents, injuries and body aches happened more often while doing 'riskier' trips suggests that these travellers were taking more physical risks. Despite these additional risks, no significant interruption to planned trip activities was seen.

While it was expected that the R2G travel risk score would be associated with increasing risk of adverse health outcomes during travel, it is surprising that the R2G travel risk score is not associated with the risky health behaviours during travel that are part of standard travel medicine advice (e.g. consuming raw or unwashed vegetables, mosquito protection). Further studies should follow-up with R2G high travel risk travellers to identify relevant additional risk behaviours, informing a larger discussion within the travel medicine community about what it means to have risky health behaviour during travel.

Using the R2G Questionnaire to inform the travel medicine consultation

Our results show that travellers with chronic medical conditions and behaviorally high-risk travellers have distinct risk profiles. Travellers with chronic conditions should be advised on how to access medical care during travel. High-risk travellers based on planned activities should receive more advice about rabies exposure and risks such as accidents and injuries related to physical activity. Our data also suggest that standard pre-travel advice on avoiding diarrhoea and gastrointestinal problems is inadequate, as it continues to be a persistent problem.[31–33] For high-risk travels, it is important to be properly insured (e.g. annulation, medical, repatriation). The R2G Questionnaire might also be used to inform evidence-based risk stratification for travel insurance purposes.

Limitations

There was a small number of TOURIST2 travellers for whom the travel purpose was unknown. However, a sensitivity analysis testing the degree to which associations would change by shifting the R2G points assigned for certain categories did not show significant differences in the patterns observed (Appendix D). We did not have data on the R2G questions on pregnancy, breastfeeding and adverse reaction to previous vaccines. However, those cases are thought to be rare in this setting.[28,34,35] Furthermore, the study only included participants with pre-travel consultations by travel clinics in Switzerland and only included travelling to specific countries. This may not be generalizable to all travellers or travel destinations. Even though the travel risk score assigns points to specific destinations depending on local risks (including malaria), it does not account for some fresh water related travel risks (e.g. schistosomiasis, leptospirosis). The inclusion of fresh water related health risks should be considered in future R2G studies. Since the TOURIST2 study only included travellers to relatively high-risk countries, we are not able to make statements about low- and moderate-risk travellers. In future iterations of the study, low-risk countries should also be studied to see if the risk points assigned for different destinations are appropriate. Finally, the group of travellers with very high-risk medical (>60) and travel (>160) scores was very small, and results should be interpreted with caution. Future studies should be conducted targeting these individuals in particular, as they may represent particularly important groups for personalized advice. It is also important to note that the TOURIST2 cohort travelled in 2019, immediately prior to the coronavirus pandemic. While some attitudes towards risk-taking may have changed, the TOURIST2 destinations and risk factors continue to be highly relevant during the current post-pandemic surge in travel.

Conclusion

In conclusion, the R2G risk assessment tool offers an effective, flexible means to quantify medical and travel risk using risk parameters like chronic medical conditions, travel destinations and purpose of travel, creating a personalized traveller risk profile. It also demonstrates the power of mHealth innovation in testing travel medicine tools detecting high-risk groups by tracking the actual incidence of health events during travel. In future studies, the R2G Questionnaire can be incorporated into an evidence-based pre-consultation triage system for identifying travellers at high-risk of specific outcomes. Including such a tool on the website of the clinic could also help travellers self-identify whether they need a special travel medicine consultation for a planned trip. Such a system would allow practitioners to focus their limited consultation time on advising travellers about the health risks most relevant to their personalized risk profile and planned itinerary, quickly triage low-risk travellers to other sources of travel information, and ensure that clients are better prepared for the health challenges they might face.

Supplementary data

Supplementary data are available at *JTM* online.

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Author contributions

Julian Maier (Conceptualization-Equal, Data curation-Equal, Formal analysis-Equal, Methodology-Equal, Software-Equal, Visualization-Equal, Writing—original draft-Equal, Writing—review & editing-Equal), Alexia Anagnostopoulos (Writing—review & editing-Equal), Anna Gazzotti (Writing—review & editing-Equal), Silja Bühler (Writing—review & editing-Equal), Vasiliki Baroutsou (Writing—review & editing-Equal), Christoph Hatz (Writing—review & editing-Equal), Milo Puhan (Writing—review & editing-Equal), Jan Fehr (Supervision-Equal, Writing—review & editing-Equal), Andrea Farnham (Conceptualization-Equal, Data curation-Equal, Formal analysis-Equal, Methodology-Equal, Software-Equal, Supervision-Equal, Visualization-Equal, Writing—original draft-Equal, Writing—review & editing-Equal).

Conflict of interest

The authors have declared no conflicts of interest.

Data availability

The data that support the findings of this study are available on reasonable request from the corresponding author, JM. The

data are not publicly available due to potentially identifiable information that could compromise the privacy of research participants.

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