Days until return-to-play differ for sub-categories of acute respiratory tract illness in Super Rugby players: A cross-sectional study over 5 seasons (102 738 player-days)

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Abstract

Objective: To document incidence rate and severity of specific sub-categories of respiratory tract illness (RTill) in rugby players during the Super Rugby tournament.

Design: Cross-sectional study

Methods: Team physicians completed daily illness logs in 537 professional male rugby players from South African teams participating in the Super Rugby Union tournaments (2013–2017) (1141 player-seasons, 102 738 player-days). The incidence rate (IR: illness episodes/1000 player-days) and severity [%RTill resulting in time-loss, illness burden (IB: days lost to illness/1000 player-days) and days until return-to-play (DRTP)/single illness (mean: 95% Confidence Intervals)] are reported for the following specific sub-categories of RTill: non-infective respiratory tract illness (RTnon-inf), respiratory tract infections (RTinf), influenza-like illness, infective sinusitis, upper respiratory tract infections (URTinf), lower respiratory tract infections (LRTinf).

Results: The overall IR of RTill was 2.9 (2.6-3.3). IR was higher for RTinf (2.5; 2.2-2.9) vs. RTnon-inf (0.4; 0.3-0.6) ($p<0.001$). For sub-categories the highest IR was in URTinf (1.9; 1.7-2.2), while the % illness causing time-loss was influenza-like illness (100%), LRTinf (91.7%), infective sinusitis (55.6%), and URTinf (49.0%). IB was highest for URTinf (2.0; 1.6-2.5), and the DRTP/single illness was highest for LRTinf (3.2; 2.3-4.4), and influenza-like illness (2.1; 1.6-2.8).

Conclusion: RTinf accounted for >57% of all illness during the Super Rugby tournament, and mostly URTinf. Influenza-like illness. LRTinf caused time-loss in >90% cases. URTinf, LRTinf and influenza-like illness resulted in the highest burden of illness and LRTinf caused the highest DRTP. Prevention strategies should focus on mitigating the risk of RTinf, specifically URTinf, LRTinf and influenza-like illness.

Keywords:

Illness, athletes, rugby, respiratory illness, infections, return-to-play, prevention

Practical implications:

In the Super Rugby tournament:

- Respiratory tract infections (RTinf) were responsible for >57% of all illness and were 6-times more frequent than non-infective respiratory tract illness (RTnon-inf)
- Acute upper respiratory tract infections (URTinf) (>45% of all reported illness) is the most common specific illness
- Influenza-like illness and other lower respiratory tract infections (LRTinf) are the most severe respiratory tract illnesses, causing time-loss from training and competition in >90% cases, and largest number of days lost until return-to-play per single clinically diagnosis
- More localised respiratory tract infections (e.g. infective sinusitis and URTinf) cause time-loss from training and competition in about 50% cases
- URTinf are common but less severe, whereas LRTinf and influenza-like illness are more severe illnesses, but less common
- Prevention strategies that will have the greatest impact should focus on reducing the incidence of RTinf, specifically URTinf, LRTinf and influenza-like illness

Introduction

There is an increased focus on health protection and illness prevention in elite athletes.[1-4] Acute illness presents a significant health burden to the athlete. Training days lost due to acute illness may negatively impact athlete performance.[5] Availability of players in teams is important to achieve team and tournament success.[6] Acute illness not only decreases performance and reduces the ability to sustain high intensity training,[7] but also increases the risk of serious medical complications and even sudden death during strenuous exercise.[8-9] Reduction of the incidence and burden of illness in athletes is a crucial goal of sports scientists and sport and exercise medicine clinicians.

Epidemiological data from a variety of international sports tournaments over shorter (9-18 days) and longer (months) durations, show 50% of all acute illness affects the respiratory tract (RT).[10-26] Acute respiratory tract illness (RTill) includes many sub-categories by anatomical location (e.g. upper vs. lower RT) and pathology (infective vs. non-infective).[9] Upper respiratory infective illness, are the most common cause of acute illness in athletes,[11,13-14,18-21,25] but few studies report more detailed diagnoses[22] and illness severity.[24] Time-loss and illness burden data have only been reported for the broad category of all RTill[22,24] but not for the following specific sub-categories of RTill: non-infective respiratory tract illness (RTnon-inf), respiratory tract infections (RTinf), influenza-like illness, infective sinusitis, upper respiratory tract infections (URTinf), and lower respiratory tract infections (LRTinf).

The Super Rugby tournament is unique in that it is played annually over an extensive ≈16-week period. It also comprise of intense weekly training sessions and matches each weekend.[27] This tournament requires intercontinental travel across multiple time-zones to compete. Players are therefore exposed to challenging travel and environmental conditions,

which is associated with an increased risk of illness.[22,28] For the 2010 tournament we documented a high overall incidence rate of all illness (IR: 20.7; 95% CI 18.5-23.1), with the highest incidence of illness being RTill, specifically RTinf.[22] Recently, we reported that a general **T**eam **I**llness **P**revention **S**trategy (**TIPS**) is associated with an overall 59% reduction in the IR of all illness and a 56% reduction in the IR of all RTill during a 4-year intervention period compared with a 3-year control period.[24] In the control period (2010–2012) of the **TIPS**,[24] we did not collect detailed data on specific diagnostic sub-categories of RTill. However, from 2013 onwards, more detailed data on specific sub-categories of RTill were obtained.[7]

Different sub-categories of acute RTill may: **i)** be associated with differences in the risk of serious medical complications in athletes (e.g. systemic vs. localised infections),[9] **ii)** be associated with different risk factors for illness (e.g. infections vs. non-infective illness such as allergies), **iii)** require different clinical approaches to make a successful return to sport (infections vs. non-infective illness such as allergies), **iv)** differ in the burden of illness on the team (localised URTinf, regional LRTinf and systemic illness such as influenza-like illness),[29-30] and **v)** differ in treatment and prevention strategies. More detailed information on incidence, severity and number of days lost until a player can return-to-play per single illness, in sub-categories of acute RTill is essential so that team physicians can manage illness during tournament and plan preventative strategies. The number of days until return-to-play (DRTP) per single illness has never been reported.

The aim of the current study was to describe the incidence rate (IR) and severity, including DRTP, of the specific sub-categories of RTill in the South African teams competing in the Super Rugby tournament over five consecutive seasons. There is a lack of long-term

surveillance of the incidence, severity and patterns of illness during tournaments. The need also exists for an improved understanding of the epidemiology of illness in the Super Rugby tournament. Fundamentally it will have a direct implication on the development and implementation of illness preventive measures, and in the long-term, allow for the protection of the health of the athlete.

Methods

Type of study and participant selection: This is a cross-sectional analysis. We collected data prospectively over 5 seasons (2013–2017) in the annual ≈16-week Super Rugby Union tournament. All participants were professional male rugby players from at least five South African teams. All players of participating teams were eligible for inclusion in the study. Over the 5 years data were collected for a total of 1141 player-seasons. Team physicians were provided with detailed information on the study. They informed all players and obtained signed consent from each player. Research ethics approval was received from both the Research Ethics Committees of the University of Cape Town (REC number 736/2013) and the University of Pretoria (432/2015 and 343/2017). Partial funding was provided by the IOC Research Centre of SA and South African Rugby. Representatives of these organisations are either authors or are acknowledged. This information was disclosed in the conflict of interest document. All authors approved the publication of this paper.

Illness data collection: During the tournament period, and for each of the 5 years, the team physicians recorded all illness episodes on a daily basis. Detailed methods on data collection are described in previous publications.[22,25] In summary, a custom-designed web-based application system was used[22] with online illness forms and the following data were collected daily: number of players in the squad, the type of day (rest day, training day or match day),

location of the squad and detailed illness data. All illness data were classified into sub-categories by organ system and by pathology (infective and non-infective). A list of specific final clinical diagnoses for illness in each organ system was provided. Acute infective illness was diagnosed clinically by the physician, based on the presence of the following general symptoms and signs: clinical signs of a localised infection, presence of a fever with other systemic signs including general malaise, general body aches, headache and resting tachycardia. Days lost until return-to-play as a result of illness was estimated at the time when the player reported the illness, and was based on the team physicians substantive clinical experience. Actual time-loss days were not reported.

Calculation of player-days: Total player-days were calculated as the sum of the total team tournament-days, over the annual 16-week period, for each team in each year. The dates the tournament started and finished, were different for each team. Per year, the first and last match played also depended on team performance and games won, and if a team was able to advance to the quarter final, semi-final or final. The daily squad size varied from 19 - 49 players per team per day, as squad size was often reduced during international travel. The total player-days per year, was calculated as:

Total team tournament-days × daily squad size (for each day) = Total player-days (for each year)

Definitions: A medical illness was defined as '*any physical complaint (not related to injury), symptom or sign presenting in a player that required medical attention from the team physician on a specific day*'.[3,22,25,31] A time-loss illness, indicative of severity of illness, was defined as '*any medical illness requiring medical intervention resulting in a loss of training or match play of ≥1 day'*.[22] Medical attention and time-loss illnesses were documented. Days

until return-to-play were defined as '*the estimated number of days that have elapsed from the date of illness onset to the date of the player's return to full participation in team training and availability for match selection*.'[31]

Measures of outcome: Incidence rate (IR) of illness: The IR was calculated as illness episodes per 1000 player-days, with 95% Confidence Intervals (95% CI),[32] for all RTill and specific sub-categories of RTill: non-infective respiratory tract illness (RTnon-inf), respiratory tract infections (RTinf), influenza-like illness, infective sinusitis, upper respiratory tract infections (URTinf), and lower respiratory tract infections (LRTinf).

We used three outcomes to measure severity of illness:

- *Percentage time-loss illness:* calculated as as the % of illness in each sub-category of RTill that resulted in time-loss illness (defined as ≥1 day lost from training or match play).[22]
- *Illness burden (IB):* calculated as the number of days lost due to RTill relative to exposure, reported as days absent per 1000 player-days.[29-30]
- *Days until return-to-play (DRTP) per single illness:* calculated as the estimated number of days before returning to play. These include all days from illness onset until medical clearance to return to full sports participation and competition.

Statistical analysis: Means with standard deviations (SD) and ranges were used to describe continuous variables. Frequencies and proportions were used to describe the number and percentage of respiratory illnesses. Illness data were in the form of counts, which represented the number of RTill for each day the team remained in the tournament. Incidence rates (IR) and Illness Burden (IB) were estimated using Poisson Generalized Estimated Equation (GEE) models with an offset equal to 1/1000 in order to produce estimates expressed as per 1000

player days. Incidence rate ratios (IR ratios) and Illness Burden ratios (IB ratios) were estimated from the models as measure of association between infective and non-infective illnesses. To account for within-player and -team correlations due to repeated measurements and clustering within team, we used a player within team nested correlation as working correlation, and robust standard errors were produced using the sandwich estimator. In order to produce estimates for DRTP only illness records were included as per the outcome. No correlation was taken into account for DRTP estimates and ratios between infective (RTinf) and non-infective illness (RTnon-inf) due to low sample sizes and the unbalanced nature of infective and non-infective illness numbers. All analysis was done using SAS 9.4. A 5% level of significance was used.

We constructed a RTill risk matrix, depicting the overall burden of RTill in four quadrants - Q1: low incidence, low severity; Q2: low incidence, high severity; Q3: high incidence, low severity; Q4: high incidence, high severity. An arbitrary cut-off point to define incidence and severity was ≥1 illness/1000 player-days, and ≥2 days lost per illness respectively.[33]

Results

Demographics of the player population (age, weight, height, BMI) in each season over the 5-year period is presented in Supplementary Table S1. Individual rugby players (n=537) participated in the study and a number of players participated in multiple years. The total number of players per season and player-days (all, training, match) for all players are shown in Supplementary Table S2. Player influx over the five consecutive seasons is illustrated in Supplementary Diagram S3.

Incidence rate (IR) of illness: In this 5-year study period, 456 illnesses were reported. The IR (per 1000 player-days: 95% CI) of all illness was 4.3 (95% CI 3.9-4.8), with 359 infections (78.7% of all illness, IR: 3.4; 95% CI 3.1-3.8) in all organ systems. A total of 305 RTill (two-thirds of all illness) were reported (IR: 2.9; 95% CI 2.6-3.3). The IR for RTinf was significantly higher ($p<0.001$) compared to RTnon-inf (IR ratio: 6.5; 95% CI 4.5-9.2). Within other sub-categories the highest IR was URTinf, followed by influenza-like illness. For sub-groups of RTnon-inf, the IR was highest for allergies, specifically allergic rhinitis and allergic sinusitis. (Table 1)

[Insert Table 1 here]

Severity of illness: Of all 305 RTill diagnosed, 49.2% (n=150) were time-loss illnesses (≥1 day). Sub-categories resulting in the greatest % of time-loss illness were influenza-like illness and LRTinf. About 50% of acute infective sinusitis and URTinf resulted in time-loss illness, while only about 10% of RTnon-inf resulted in a time-loss illness. (Table 1)

In this study period a total of 332 days were lost due to RTill. The overall illness burden (IB: per 1000 player-days; 95% CI) of RTill was 3.3 (95% CI 2.7-4.1). The IB of RTinf was significantly higher ($p<0.001$) compared to RTnon-inf. The IB for specific sub-categories was highest for URTinf. (Table 2)

[Insert Table 2 here]

During this study period, on average, 1.1 days (95% CI 1.0-1.2) from tournament play was lost per single RTill. RTinf resulted in significantly higher DRTP per single illness compared

with RTnon-inf ($p<0.001$) (DRTP ratio: 10.4; 95% CI 4.3-25.3). LRTinf resulted in the highest DRTP per single illness followed by influenza-like illness. Although LRTinf represented less than 4% of all RTill, the DRTP was longer for a player with LRTinf (>3 days), compared to the other sub-categories of RTill (≤2 days). (Table 2)

The risk matrix (Q1 – Q4, Figure 1) shows no sub-categories of RTill in Q4 (high incidence, high severity). LRTinf and influenza-like illness were in Q2 (low incidence, high severity), while URTinf was in Q3 (high incidence, low severity). All other sub-categories of RTill were in Q1 (low incidence, low severity).

[Insert Figure 1 here]

Discussion

In this study, we describe the incidence rate and severity, including DRTP, of specific sub-categories of RTill in the South African teams competing in the Super Rugby tournament over five consecutive seasons. The IR for all RTinf was significantly higher compared to RTnon-inf. The IR of URTinf was nearly 10-times higher, and was the specific diagnosis in >44% of all illness. LRTinf and influenza-like illness resulted in time-loss illness in >90% of diagnosed cases, while time-loss occurred in about 50% of acute infective sinusitis and URTinf cases. URTinf had the highest IB, and this was 5-times higher compared to all other sub-categories of RTill. On average, any player diagnosed with a RTill will lose 1.1 DRTP, while a player with LRTinf or influenza-like illness will have a mean DRTP of ≈3.2 and ≈2.1 days respectively.

In studies on single sports over multiple seasons, an IR (per 1000 player-days) of RTill of 0.9 (95% CI 0.8-0.9) over a 4-year multiple season period (2011–2014) was reported for professional football teams in Europe (UEFA Champions League).[12] In our study on Super Rugby players over a 5-year period, the IR of RTill was 2.9 (95% CI 2.6-3.3) and considerably higher than the IR of RTill in the UEFA football study. Potential reasons for a higher IR of RTill in Super Rugby players may be a higher risk of infectious disease transmission because of increased physical contact between players during tournaments, higher match frequency, and intercontinental travel across multiple time-zones during the tournament.[23] We could not compare data on the IR of RTill in our study to RTill data from other tournaments since only incidence proportion (IP)[13,15-18] was reported in other studies. The duration of the Super Rugby tournament is also much longer than other tournaments/competitions, therefore the exposure differed substantially.

In our study population, RTinf was more common than RTnon-inf (IR ratio: 6.5; 95% CI 4.5-9.2; $p<0.001$). Studies reporting the diagnostic sub-categories of infective- and non-infective RTill over consecutive seasons are limited, making comparison of our results of RTill sub-categories to results from most other studies difficult. We note that RTinf is reported as the leading cause of illness during single season events of shorter duration i.e. the 2016 Olympic Summer Games in Rio (76.4%), and the London 2012 Paralympic Games (28.6%).[26] However, we could not compare the IR of RTinf in our study to these studies since IR of RTinf per exposure (1000 player-days) was not reported.

We showed the most common specific sub-category of RTill was URTinf (IR: 1.9; 95% CI 1.7-2.2), followed by influenza-like illness (IR: 0.2; 95% CI 0.1-0.3). Our IR of URTinf was slightly lower in comparison to one previous study we conducted during a single season of the

Super Rugby tournament (IR of URTinf: 3.3; 95% CI 2.8-3.8).[22] We are not aware of other published studies reporting the IR (per 1000 player-days) of sub-categories of RTill in single and/or multi-sport coded events or tournaments.

The severity, and therefore the clinical impact of illness in athletes during a tournament, can be measured by the % of illness cases that result in time-loss, the IB, and the DRTP per illness. In our study, RTinf resulted in time-loss in 55.5% of cases, and was higher than the 25.5% we reported for RTinf in our previous study over one season.[22] No other studies reported the % time-loss illness for RTinf, hence there are no other data to compare. We do note the % time-loss illness for RTinf in our study is more than 2-times higher than the % time-loss illness reported for all RTill during IAAF championships (19.1-21.7%).[19,21]

A novel aspect of our study is that we also reported % time-loss and DRTP for specific sub-categories of RTill. In >90% cases, influenza-like illness and LRTinf resulted in a time-loss illness, while time-loss occurred in about 50% of acute infective sinusitis and URTinf cases. RTnon-inf resulted in time-loss in only about 10% cases. The average DRTP per single RTill was 1.1 days, and per specific RTill DRTP was highest for LRTinf (3.2 days) and influenza-like illness (2.1 days). Therefore, severity of RTill in athletes is related to infective illness, particularly RTinf associated with regional (LRTinf) or systemic involvement (e.g. influenza-like illness). More localised infections (URTinf, sinusitis) had less impact on the DRTP and therefore availability of players during tournaments. Non-infective illness did not significantly affect DRTP.

The IB for all RTill over the 5-year study period was 3.3 (95% CI 2.7-4.1). In our study URTinf has an almost 5-times higher burden (IB: 2.0; 95% CI 1.6-2.5), compared to all other

illness. In a squad of 30 players, this translates to ≈2 players every month being diagnosed with a RTill. The only comparable prospective study in team sports other than rugby union over multiple seasons, was in the UEFA Champions League where a similar IB for all RTill was reported (IB: 3.2 days lost per 1000 player-days).[12] From our risk matrix, we can conclude that the greatest impact of any RTill prevention program will be to reduce the incidence of URTinf and the severity of LRTinf and influenza-like illness.

Our study has a number of strengths and some limitations. The main strengths are the large sample size, our prospective design over a 5-year period, and the use of standardised data collection methods with accurate and consistent documentation of illness data by team physicians using clinical criteria. To our knowledge, this is the first study that reports on specific clinically diagnosed sub-categories of RTill. The fact that it was a clinical diagnosis by team physicians, rather than confirmation of the cause of illness by special investigations is a limitation. This limitation is consistent across all illness surveillance studies in sport settings to date. More precise pathological diagnoses of illness, confirmed by special investigations, would be important in future. Additional limitations are that time-loss was estimated by team physicians at the time of diagnosis, and not the final actual return-to-play. Reporting the actual time-loss days or the specific day of return-to-play, is not always feasible, and therefore disclosed as an estimate. Days until return-to-play are estimated in the majority of published papers on illness. Pre-season medical screening data on the individual player's illness risk profile was not available. Finally, the generalizability of our data to other sporting codes may be limited since only Rugby Union players participating in a unique tournament involving substantial intercontinental travel were studied.

Conclusion

During the 5-year Super Rugby tournament, RTinf accounted for >57% of all illness. The IR for all RTinf was significantly higher ($p<0.001$) compared to RTnon-inf. URTinf was the most common specific RTill. The most severe RTill were influenza-like illness and LRTinf, which resulted in time-loss from training and competition in >90% cases, and the largest number of DRTP per single clinically diagnosis. The RTill associated with the highest overall IB were URTinf, LRTinf and influenza-like illness. Reporting more detailed IR and illness severity in specific clinical sub-categories of RTill, may enable team physicians to provide medical care more precisely. In future, more targeted interventions for specific clinical sub-categories of RTill could be developed. The next step is to identify specific risk markers for RTill and sub-categories of RTill, which will be a key element to develop specific prevention strategies. Prevention strategies that will probably have the greatest impact on mitigating the risk of RTill will be to prevent infections associated with regional and systemic involvement.

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Table 1: The number, percentage (% of all illness), % time-loss illness (≥1 day) and incidence rate (IR per 1000 player-days; 95% CI) for infective- and non-infective RTill, and specific sub-categories of RTill in the study period (2013–2017)

Sub-categories of RTill	RTill n (% of all Illness)	Time-loss RTill n (% of RTill)	IR / 1000 player-days (95% CI)
Infective (RTinf)	**263 (57.7)**	**146 (55.5)**	**2.5 (2.2-2.9)***
URTinf	202 (44.2)	99 (49.0)	1.9 (1.7-2.2)
Influenza-like illness	21 (4.6)	21 (100)	0.2 (0.1-0.3)
LRTinf	12 (2.6)	11 (91.7)	0.1 (0.1-0.2)
Acute infective sinusitis	9 (2.0)	5 (55.6)	0.1 (0.1-0.2)
Acute infective rhinitis	7 (1.5)	2 (28.6)	0.1 (0.0-0.1)
Pneumonia	1 (0.2)	1 (100)	**
Non-specific RTinf	11 (2.4)	7 (63.6)	0.1 (0.1-0.2)
Non-infective (RTnon-inf)	**42 (9.2)**	**4 (9.5)**	**0.4 (0.3-0.6)**
Allergic rhinitis	17 (3.7)	0 (0)	0.2 (0.1-0.3)
Allergic sinusitis	15 (3.3)	2 (13.3)	0.1 (0.1-0.2)
Non-specific RTnon-inf	10 (2.2)	2 (20.0)	0.1 (0.1-0.2)

URTinf: Acute upper respiratory tract infections

LRTinf: Acute lower respiratory tract infections

Influenza-like illness: Defined as an acute respiratory infection with a measured fever of ≥38 C°, cough, and onset within the last 10 days (World Health Organization case definition)[34]

n: Number of illnesses

%: Percentage of all illness

IR: Incidence Rate (per 1000 player-days)

95% CI: 95% Confidence Interval

% of RTill: Percentage time-loss of all in the sub-category (n time-loss RTill/n RTill)

*Significantly higher compared with non-infective ($p<0.001$)

**Number too small to calculate IR accurately

Table 2: The total days lost, illness burden (IB per 1000 player-days; 95% CI), and the days until return-to-play (DRTP) per single illness, for infective- and non-infective RTill and specific sub-categories of RTill in the study period (2013–2017)

Sub-categories of RTill	n	Total days lost	IB / 1000 player-days (95% CI)	DRTP / single illness (mean) (95% CI)
Infective (RTinf)	**263**	**327**	**3. 2 (2.6-4.0)***	**1.2 (1.1-1.4)***
URTinf	202	199	2.0 (1.6-2.5)	1.0 (0.9-1.1)
Influenza-like illness	21	44	0.4 (0.3-0.7)	2.1 (1.6-2.8)
LRTinf	12	38	0.4 (0.2-0.7)	3.2 (2.3-4.4)
Acute infective sinusitis	9	8	0.1 (0.0-0.2)	0.9 (0.4-1.8)
Acute infective rhinitis	7	5	0.05 (0.0-0.2)	0.7 (0.3-1.7)
Pneumonia	1	15	0.2 (0.0-1.0)	**
Non-specific RTinf	11	18	0.2 (0.1-0.4)	1.6 (1.0-2.6)
Non-infective (RTnon-inf)	**42**	**5**	**0.05 (0.0-0.1)**	**0.1 (0.1-0.3)**
Allergic rhinitis	17	0	**	**
Allergic sinusitis	15	2	**	**
Non-specific RTnon-inf	10	3	**	**

URTinf: Acute upper respiratory tract infections

LRTinf: Acute lower respiratory tract infections

Influenza-like illness: Defined as an acute respiratory infection with a measured fever of ≥ 38 C°, cough, and onset within the last 10 days (World Health Organization case definition)[34]

n: Number of illnesses

95% CI: 95% Confidence Interval

*Significantly higher compared with non-infective ($p<0.001$)

**Number too small to calculate accurately

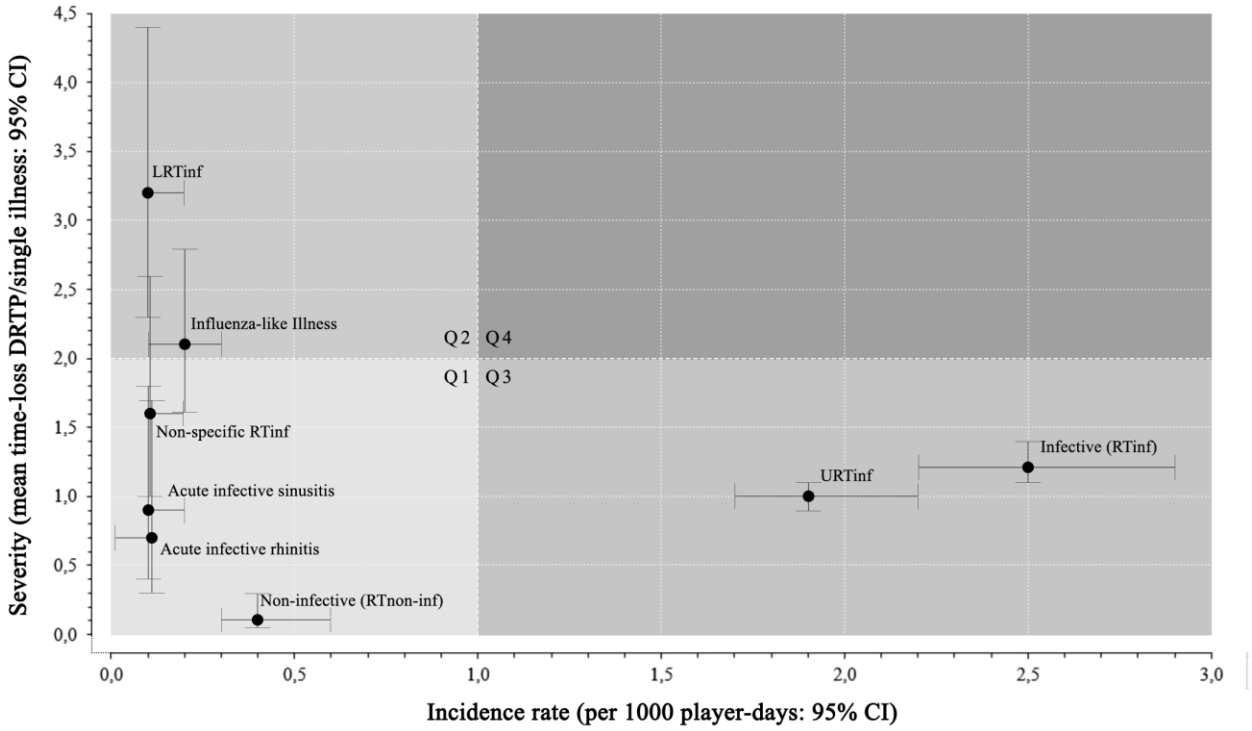


Figure 1: Risk matrix illustrating the overall burden of specific sub-categories of infective and non-infective RTill in the study period (2013–2017)

Overall burden of RTill divided in four quadrants: Q1 low incidence, low severity; Q2 low incidence, high severity; Q3 high incidence, low severity; Q4 high incidence, high severity.

Arbitrary cut-off points: Incidence ≥1 illness/1000 player-days; Severity ≥2 days lost per illness

95% CI: 95% Confidence Intervals

Supplementary Table S1: The demographics of the player population (age, weight, height, BMI)(mean, SD and range) per season during the annual Super Rugby tournaments (2013–2017)

		2013 Season	2014 Season	2015 Season	2016 Season	2017 Season
Age (years)*	**Mean (SD)**	25.11 (3.50)	24.35 (3.26)	24.39 (3.28)	24.12 (3.00)	24.43 (3.20)
	Range	18 - 35	18 - 36	19 - 37	19 - 34	18 - 35
Height (m)	**Mean (SD)**	1.87 (0.07)	1.86 (0.07)	1.87 (0.07)	1.86 (0.08)	1.86 (0.08)
	Range	1.68 – 2.08	1.69 - 2.05	1.69 - 2.09	1.67 - 2.06	1.63 - 2.09
Weight (kg)	**Mean (SD)**	101.88 (12.59)	101.96 (12.82)	101.36 (12.46)	101.29 (13.36)	101.16 (13.12)
	Range	75 - 127	72 - 132	77 - 133	67 - 136	63 - 132
BMI (kg/m^2)	**Mean (SD)**	29.24 (2.92)	29.33 (3.09)	29.10 (3.03)	29.16 (3.15)	29.30 (3.16)
	Range	23.96 – 38.77	22.07 - 38.77	23.29 – 39.38	23.18 - 39.38	23.37 - 39.14

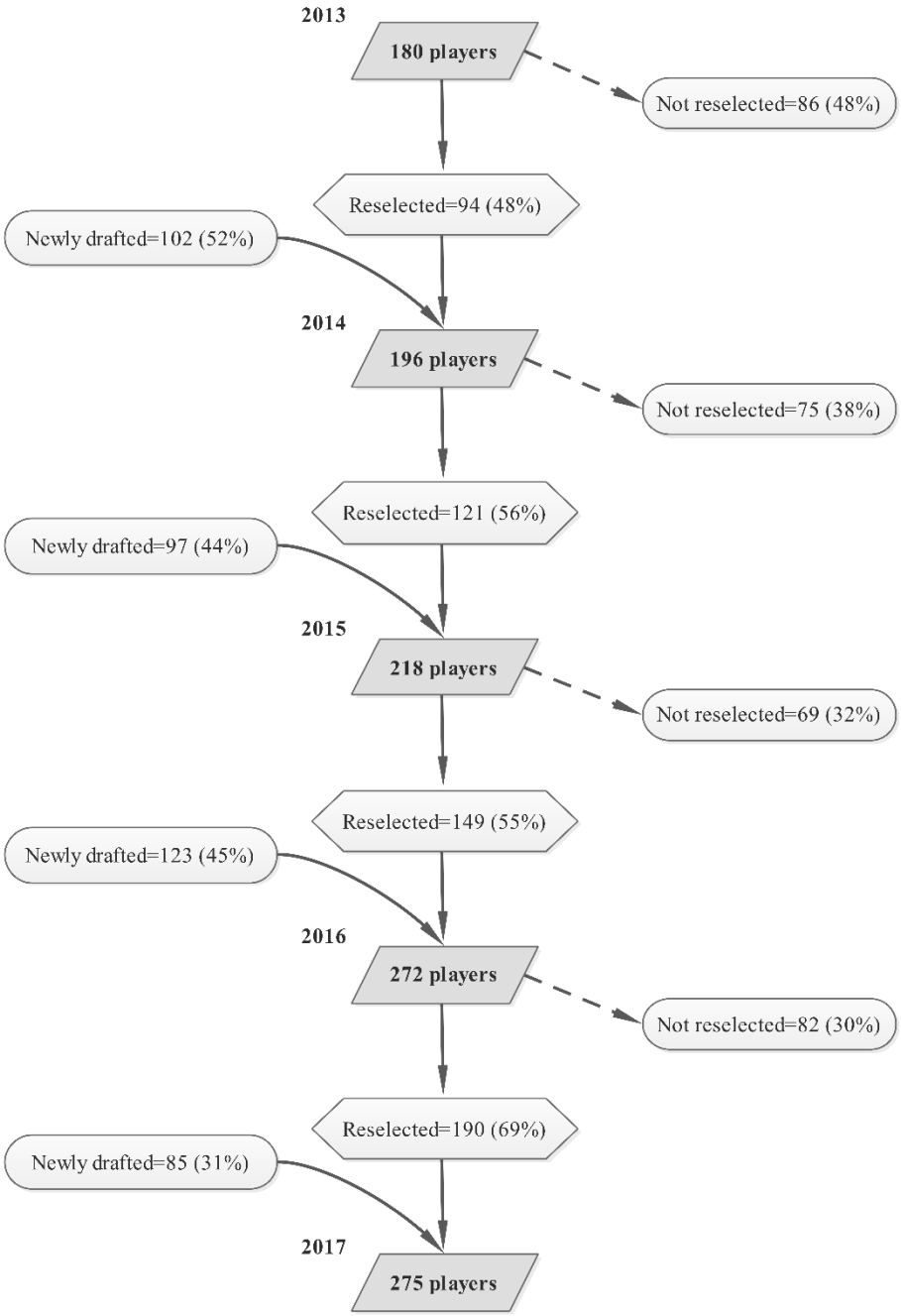
Results presented as Means with SD, Range

*****Age: Calculated in years, as at the 1st January of each season. The squad changed with the annual influx of new younger players.

Supplementary Table S2: The number of players and total player-days per season in the study period (2013–2017)

	2013 Season	2014 Season	2015 Season	2016 Season	2017 Season	Total 2013–2017 period
Number of players	180	196	218	272	275	**1 141***
Total player-days	16 715	16 118	21 406	23 817	24 682	**102 738**
Number of teams per season	5	5	5	6	6	**22**

*Several players participated in multiple years. In total 537 individual rugby players participated in the study i.e. the same players are counted multiple times in more than one season.



Supplementary Diagram S3: Player influx over the 5 consecutive seasons in the study period (2013-2017)

%: % of new season players. Reasons for non-selection were not recorded. A number of players were selected for multiple seasons i.e. 226 players played in 1 season, 137 players played in 2 seasons, 85 players played in 3 seasons, 59 players played in 4 seasons, 30 players played in 5 seasons.