Skin Rash Cliff

Branch Baseline

Rash is a general term for a temporary skin eruption. (Merck Manual, 2009) For the purposes of this medical condition, these are in the category of contact dermatitis and atopic or allergic dermatitis. Most of these rash types typically demonstrate little or no elevation above the skin surface. (Merriam-Webster, 2010) Skin rashes have been reported regularly during the US space program.

Incidence Data Included in the Model

The model imports the following incidence information from the IMM database: incidence data category, space adaption status, incidence data, incidence and occurrence distribution data and incidence data characteristics. Data category defines the type of data available for incidence calculations (i.e. raw data vs. fixed data). Space adaptation identifies medical events that onset occurs in the first 5 days of flight and does not reoccur. Incidence values vary by data category and define the number of medical events per person-year or medical events per person-at-risk for each medical condition. Incidence values can be modified by crew characteristics such as gender. Modifying characteristics are noted below and incidence values are listed individually for each characteristic. Distributions are assigned to medical events incidence values and occurrences in the model. For each crew member in a given trial, the incidence and number of occurrences of each medical condition are randomly selected from these probability distributions. Detailed descriptions of the distributions are included in the IMM Technical Description Document.

Incidence	
Data Category:	In-flight
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Gamma
Occurrence:	Poisson

Data Characteristics	
Events:	120
Person Years:	45.49
Space Flight Incidence Rate (Events / Person Years):	120 / 45.49 = 2.63794240492416

Incidence Comments

Previous incidence rate reported was 3.29 (90 cases, including hyperemia, petechiae and herpes zoster). If there was a period of 24 hours or more between rashes in the same crew member this was counted as an additional case (Kerstman, 2010).

Our revised data (94 cases) include some skin infections which presented initially as skin rash (counted as two separate events), and we kept the same criterion of counting separate events if there was a period of 24 hours or more between rashes in the same crew member (Walton, 2010). It does not include petechiae, reclassified as bruising/bleeding not subungual, hyperemia, counted as allergic reaction, and herpes zoster included in the Herpes Zoster Cliff.

Tronnier reported 110 cases of dry skin/irritation/rash in STS 26 to STS 74 post-flight debriefs, from 1988 to 1995 (Tronnier, 2008). Of note, our in-flight compilation includes 123 cases of dry skin (112 in STS, 6 in ISS and 5 in Skylab) not considered as a skin rash, and therefore are not included in this CliFF incidence.

Added incidence information from the Real World System data. Add 26 new medical events (15 ISS to the existing 6 and 11 STS to the existing 56). Added 18.17 person years to the 27.36 for a new total of 45.53 person years (Saile, 2017).

Updated the Person-Years based on the revised real world system integrated incidence data. The integrated person years changed from 18.17 to 18.13 so the conditions person years changed from 45.53 to 45.49 (Saile L., 2017)

Information Regarding Prevention

Disqualifying criteria includes in the General category: History of sensitivity or demonstrated allergy of sufficient severity so as to interfere with the mission. In the Skin category adherent scars that interfere with the wearing of personal equipment or that impair movement to the extent that emergency egress would be impeded; infections of the skin, systemic or superficial, if communicable, extensive, or not amenable to treatment; and any skin disorder, acute or chronic, that is severe enough to cause interference with emergency egress, wearing of flight equipment, or successful mission completion. (International Space Station Program, 2002)

Other:

Location of skin rashes in space flight include scalp, face, neck, chest, back, trunk, abdomen, arms/hands, genitals, and buttocks/anal. Presumed diagnoses were acne, allergic cholinergic urticaria, contact dermatitis, eczema, and psoriasis. (Kerstman, 2010)

The proposed etiologies include low humidity environment, retained moisture from sweat/wet clothing, prolonged use of maximum absorbency garment (MAG), poor hygiene, soap/no rinse shampoo/cleaning solution, lotions, oxygen mask irritation, extravehicular activity (EVA) suit gloves, EVA suit electrodes, ECG electrodes, G-suit abdominal pressure bladder, cycle Ergometer back rest, cycle Ergometer harness, and urine collection devices (Kerstman, 2010).

Hygiene constraints are possible causes of skin rashes , e.g. use of wipes and cleansers; immune system changes of space flight; allergy/hypersensitivity to foods like peanut butter or canned fish, clothing fabrics, jewelry (nickel), medications, or hygiene products; bacterial, viral, or fungal infections; atypical Herpes simplex virus (HSV); photo-dermatitis; and cutaneous decompression sickness (DCS) (Drago, 2002) (Kerstman, 2010).

Possible mitigations comprise allergy testing/patch testing of person, allergy testing of products (off-gassing), avoidance of irritants, temperature control (sweating), and prevention of spread among the crew.

Possible work-up consists of EBV, IgE, Complement (C3a, 4a, 5a), C1 esterase, ESR, Cytokines (Interleukin-5 and 13), CLA+ T cell lymphocyte, thyroid antibodies, prostaglandins (D2), leukotrienes B4, C4, D4 and hormones; mast cells, basophils, eosinophils, immune complexes, Cyclic Nucleotides, and HLA (A2) (Dworzak, 1999)

Potential operational impacts of skin rashes include symptoms interfering with operational activities (e.g. EVA), facial rashes interfering with Program Assessment Office (PAO) events, difficulty wearing space suits/gloves, adverse side effects of treatments (e.g. sedation), exacerbation of rash by exercise countermeasures, transmission between crew members if infectious, inadequate resources available to treat the rash, manifestation of a serious systemic disease or development of anaphylaxis, and severe uncontrolled symptoms requiring evacuation. (Kerstman, 2010)

Complaints of itching, dryness, thinning of the skin, increased sensitivity, delayed healing of wounds, and increased tendency to infections during space flight have been reported anecdotally. .There are no systematic studies on the effects of space flight on the human skin. The SkinCare project was a pilot study conducted by the European Space Agency (ESA). However this study does not to fulfill the requirements of comprehensive validation mainly because of including only one subject; failures in data collection points because of scheduling conflicts; and equipment failures in analyzing the visiometer readings. Study results indicated delayed epidermal proliferation of cells and loss of elasticity of the skin, confirmed by ultrasound. (Tronnier, 2008)

Incidence Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
Walton, 2010	1	Incidence
Saile L., 2017	1	Incidence

Incidence data not included in the model

The model pulls the incidence information from the IMM database ... the information shown below does not go into the model.

Incidence	
Data Category:	Fixed
Space Adaptation:	No
Incidence Type:	Rate

Distribution Data	
Incidence:	Fixed
Occurrence:	Poisson

Data Characteristics	
Fixed Rate:	0.044

Incidence Comments

The exact incidence in the United States is difficult to assess because many individuals who are affected may not seek medical attention, or the condition is treated with non prescription items (Hanifin, 2007) (Hanifin, 2004) (Beltrani, 2003) (Larsen, 2002).

Skin conditions account for 7% of outpatient visits to primary care providers in the U.S. In 2001, there were 37.9 million visits to office-based dermatologists for skin conditions in the U.S. (0.136 visits/person-year) (Kerstman, 2010). In 2001, National Ambulatory Medical Care Survey (NAMCS) reported that there were 12.1 million visits to physician offices for skin rashes in the U.S. (0.044 visits/person-year) (Cherry, 2003).

Skin rash is among the 20 leading reasons for visits to the emergency department 1.5% male and 1.6% female (Pitts, 2008)

Alternative Incidence Data

Contact dermatitis is one of the most common forms of occupational skin disease in the United Kingdom, affecting 100 patients per 100,000 workers annually, 0.001 person-year (Alexandroff, 2008). This incidence rate differs from The Health and Occupational Reporting Network (THOR) study in the same area

In the U.K. (2002-2005) the average annual incidence rate of work-related skin disease reported to THOR by dermatologists (EPIDERM) was 91.3 [95% confidence interval (CI) 81.8-101.1] per million, and by occupational physicians (OPRA) was 316.6 (95% CI 251.8-381.3) per million. Most reports were of contact dermatitis: dermatologists 68.0 (95% CI 59.8-76.2) per million, occupational physicians 259.7 (95% CI 200.8-318.6) per million. For contact urticaria the incidence rate was (EPIDERM) 3.1/per million, (95% CI 1.8–4.4); OPRA 12.6, (95% CI -0.7–25.9).

For cases of allergic contact dermatitis the mean age reported to EPIDERM was 39.3 years (SD 13.3), and was slightly higher (41.8 years, SD 13.5) for OPRA cases. Irritant contact dermatitis cases were somewhat younger than the allergic group (35.9 years, SD 13.1 in EPIDERM; 38.7 years, SD 11.2 in OPRA). Rates were higher in females, but occupations included were predominantly female. The information produced by THOR is an important source for calculating incidence rates of occupational skin disease. The Incidence rates for occupational dermatoses were calculated using THOR data as numerators, and Labour Force Survey data or information from the most recent U.K. survey on provision of occupational physician services as denominators (Turner, 2007).

Globally, Thyssen reviewed prevalence studies in different countries to determine a median prevalence. The median prevalence of contact allergy to at least one allergen was 21.2% (range 12.5-40.6%), and the weighted average prevalence was 19.5%, based on data collected on all age groups and all countries between 1966 and 2007. (Thyssen, 2007)

Treatment and Outcomes

Based on the best evidence available best and worst case percentage ranges are assigned. The medical condition is divided into three clinical phases in all three clinical phases a functional impairment is assigned. The clinical phase I and II's functional impairments remain for the duration for that respective clinical phase. The function impairment in clinical phase III represents final impairment for this medical condition and remains for the rest of the mission. Other mission end states include evacuation and loss of crew life.

The IMM checks medical resource availability once the number of medical events and scenarios has been established. If there is not sufficient essential resources called out in the CliFF, then the medical condition will go down an untreated best or worst case scenario pathway.

The table below summarizes the treated and untreated best and worst case scenarios.

	Clinical Phase I Diagnosis & Initial Treatment[1]		**Clinical Phase II On-going Treatment / Convalescence[2]**		**Clinical Phase III Recovered / Mission End State[3]**		
	FI[*] (%)	**Duration (hrs)**	**FI[*] (%)**	**Duration (hrs) (Min - ML - Max)**	**FI[*] (%)**	**EVAC[**] (%)**	**LOCL[**] (%)**
ISS-based Treatment (best case scenario %: 96.69 - 97.52)	100	0.33	0 - 9	24 - 60 - 96	0	0	0
ISS-based Treatment (worst case scenario %: 2.48 - 3.31)	100	0.33	1 - 27	240 - 288 - 336	0 - 9	0	0
Untreated Best Case	0	0	1 - 27	24 - 60 - 96	0 - 9	0	0
Untreated Worst Case	0	0	11 - 42	240 - 288 - 336	1 - 42	0 - 1	0

[1]Clinical Phase I: Clinical phase I covers only the initial assessment of the affected crew member to define his or her medical condition, and completion of appropriate initial treatment to stabilize the crew member. While the affected crew member is being assessed, he or she is not able to perform any assigned tasks, thus Functional Impairment during this phase is considered 100%. In the untreated case, there is no diagnosis performed or treatment given, therefore Functional Impairment and Duration will always be "not applicable".

[2]Clinical Phase II: On-going Treatment and Convalescence- During clinical phase II, the affected crew member is receiving any appropriate follow-on treatment for his or her medical condition to allow the crew member to recover as much as he or she is able to recover in the ISS environment. Clinical phase II also encompasses relapses or reoccurrences of the same original medical condition in clinical phase I necessitating additional treatment or recovery time due to unsuccessful primary treatment response. The duration in Clinical Phase II is expressed in minimum, most likely (ML) and maximum hours. This was updated for future capabilities in IMM but is currently not being used by the model.

[3]Clinical Phase III: Recovered/Mission End State- Clinical phase III is reached once the affected crew member has recovered from the medical condition as much as he or she is able to recover in the ISS environment. This may or may not be recovery from the given medical condition to the full extent possible. If this "recovered" state results in an evacuation or loss of the crew member, this will be noted in the mission end state results.

*Functional Impairment (FI) is a measure of the affected crew member's health and performance ability.

**Two mission end state results are addressed in the CliFF: 1) Evacuation (EVAC) - crew and patient are evacuated from the spacecraft due to the medical condition, and 2) Loss of crew (LOCL) - death of affected crew member due to medical condition. EVAC is considered as an end state result if any of the following criteria are met: 1) potential LOCL, 2) potential significant permanent impairment, or 3) potential intractable pain. Probability distributions are assigned for each range of values within the Table of Treatments and Outcomes.

Refer to the Integrated Medical Model Technical Document for more information on how risk is reported by the IMM, Crew Health Index (CHI) and Quality Adjusted Mission Time calculations.

Definition and Probability of Best and Worst Case Scenario: (includes definitions of best and worst case scenarios and identifies the probability of those scenarios.)

Scenario Comments

The **best case scenario is defined** as mild to moderate and uncomplicated skin rash that responds to treatment.

The **worst case scenario is defined** as a moderate to severe skin rash, covering an extensive area and that might be refractory to treatment.

Percentages of how often best versus worst case scenarios occur

The diagnosis of a skin rash can usually be made through visual inspection and does not require specialized equipment. The treatment of a skin rash usually requires topical and/or oral medications. Overall, the diagnosis and treatment of skin rashes is usually simple and very effective. Therefore, mitigation efficiency is considered very high.

Bacterial or fungal infections are addressed in the Skin Infection CliFF; Herpes Zoster in the Herpes Zoster CliFF, and anaphylactic reaction in the Anaphylaxis CliFF.

Skin conditions could be a particular problem in an artificial atmosphere, because the healing process may be prolonged. In a study of health of US Navy submarine crew during periods of isolation, skin conditions ranked among the top five most common categories of morbidity among both officers and enlisted men; however, the risk was very low, about 3.1 per 100 person-years at sea among officers and 8.1 per 100 person-years among enlisted men potentially mission-impacting medical events reported among officers aboard submarine patrols were rare (36.3 per 100 person-years underway; The officers are most analogous to current space program participants. (Thomas, 2003)

In a health risk perception survey, the experts rated skin disorders as the most likely to occur, but which would have little effect on mission completion or astronaut health, ranked 8th and 9th respectively among 9 disease categories. (Billica, 1996)Summers estimated the likelihood of evacuation in 0.01 events for person year evacuation rate. Skin conditions are not listed among the possible causes for evacuation (Summers, 2005).

Dermatological events are among the most frequent. As most of these conditions do not represent medical emergencies, they could be treated by merely taking medications while on board, if available (Risin, 2009). On the other hand, risks of exposure of crew members to exotic compounds are high; maintenance operations in space station demand close physical contact with substances such as ethylene glycol, cadmium, nickel and urea. Aggressive treatment is necessary to minimize performance degradation. EVA operations in particular cannot be effectively conducted while the crewmember has a distracting dermatological problem (Marshburn, 2008)

Based on Real World System data set, there were 26 events and 3 of them were worst case. Since we now have worst case scenarios, which did not have before, we can use the empirical data so the worst case scenario would be 11.54% (3/26). Thus the best case scenarios would be 88.46% (23/26) (Saile L., 2017).

Best Case Comments

By definition Functional impairment (FI) in **Clinical Phase I is 100%** and duration is estimated in 20 minutes to follow the procedures indicated in the ISS Medical Checklist for skin rash, i.e. to locate skin treatment procedure in the ISS medical checklist, un-stow the medications, and photo-document the rash. In **Clinical Phase II** FI is estimated to be 0 to 9%. **Class 0**, 0% Skin disorder signs have been present in the past but are currently present <1% of the time, no medication is necessary, no interference with activities of daily living (ADL). **Class 1**, 1 to 9%, signs and symptoms are present 1 to 30% of the time; may intermittently require treatment with topical medications; when signs and symptoms are present there is minimal interference with ADLs. (American Medical Association, 2008) We did not find a specific treatment duration time rather indication to treat until the rash resolves (Merck Manual, 2010). Topical treatment duration is estimated in 24 to 96 hours, as in this scenario rash is uncomplicated and responds to treatment. In **Clinical Phase III** recovery is expected in the best case scenario and FI is estimated in 0%, **Class 0**, skin disorder signs have been present in the past but are currently present <1% of the time, no medication is necessary, no interference with activities of daily living (ADL) (American Medical Association, 2008). EVAC and LOCL is not expected (Billica, 1996).

Worst Case Comments

By definition Functional impairment (FI) in **Clinical Phase I is 100%** and duration is estimated in 20 minutes, similar to the best case scenario. In **Clinical Phase II**, FI is estimated in 1 to 27%. **Class 1**, 1 to 9%, signs and symptoms are present 1 to 30% of the time; may intermittently require treatment with topical medications; when signs and symptoms are present there is minimal interference with ADLs. **Class 2, 11 to 27%** signs and symptoms are present > 30 to 60%% of the time; often require treatment with topical or systemic medications; when signs and symptoms are present there is mild interference with some ADLs (American Medical Association, 2008). Duration is estimated to be 10 to 14 days (Merck Manual, 2010).

In **Clinical Phase III**, FI is estimated to be 0 to 9%. **Class 0**, 0% Skin disorder signs have been present in the past but are currently present <1% of the time, no medication is necessary, no interference with activities of daily living. **Class 1**, 1 to 9%, signs and symptoms are present 1 to 30% of the time; may intermittently require treatment with topical medications; when signs and symptoms are present there is minimal interference with ADLs (American Medical Association, 2008). EVAC and LOCL is not expected (Billica, 1996).

Untreated Best Case Comments

Clinical Phase II, FI is estimated in 1 to 27%, similar to the best case scenario but there is no treatment available. **Class 1**, 1 to 9%, signs and symptoms are present 1 to 30% of the time; when signs and symptoms are present there is minimal interference with ADLs.

Class 2, 11 to 27%, signs and symptoms are present > 30 to 60%% of the time; when signs and symptoms are present there is mild interference with some ADLs (American Medical Association, 2008). Duration is 1 to 4 days (Merck Manual, 2010). Symptoms may resolve or improve with avoidance of the irritant, thus in **Clinical Phase III**, FI is estimated to be 0 to 9%. **Class 0**, 0% Skin disorder signs have been present in the past but are currently present <1% of the time, no medication is necessary, no interference with activities of daily living. **Class 1**, 1 to 9%, signs and symptoms are present 1 to 30% of the time; when signs and symptoms are present there is minimal interference with ADLs. EVAC and LOCL is not expected (Billica, 1996).

Untreated Worst Case Comments

During **Clinical Phase II**, FI is estimated in 11 to 42% when there is no treatment available; **Class 2, 11 to 27%**, signs and symptoms are present > 30 to 60%% of the time; when signs and symptoms are present there is mild interference with some ADLs.

Class 3, 30-42%, signs and symptoms are present > 60 to 90% of the time; when signs and symptoms are present there is moderate interference with some ADLs (American Medical Association, 2008). Duration is estimated to be 10 to 14 days, based in the clinical practice guidelines by the American Academy of Allergy, Asthma and Immunology (AAAAI) and the American College of Allergy, Asthma and Immunology (ACAAI) (Leung, 2004).

In **Clinical Phase III**, recovery may not occur without treatment, and FI is estimated to be 1 to 42%. **Class 1**, 1 to 9%, signs and symptoms are present 1 to 30% of the time; when signs and symptoms are present there is minimal interference with ADLs.

Class 2, 11 to 27%, signs and symptoms are present > 30 to 60%% of the time; when signs and symptoms are present there is mild interference with some ADLs. **Class 3**, 30-42%, signs and symptoms are present > 60 to 90% of the time; when signs and symptoms are present there is moderate interference with some ADLs (American Medical Association, 2008). EVAC is estimated in 0-1% (Kerstman, 2010).

Treatment and Options Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
Billica, 1996	5	EVAC
American Medical Association, 2008	3	FI
Kerstman, 2010	5	EVAC
Saile L., 2017	1	BCWC

Additional Comments

We searched PubMed using the keywords Skin rash and epidemiology, skin rash and incidence. Our search yielded 523 and 333 results; abstracts were reviewed by date and relevance. We then reviewed articles and searched for primary sources cited in selected articles. Search for skin rash and space medicine, skin rash and space flight, skin rash and astronauts yielded no results.

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
Benadryl 25 mg capsule	4	4	60	Yes	Yes	Anti allergic, for itching or drug-induced muscle-spams
Camera	1	1	1	No	No	To photo-document rash
Fluocinonide 0.05%, 30gm tube	0.1	0.38	2	Yes	Yes	Topical steroid to help control ichting and inflamation.
Prednisone 20 mg	0	6	40	Yes	Yes	Anti allergic, persistent symptoms

Resource Comments

Lotrimin was deleted because anti-fungal medications are part of the Skin Infection CliFF. A camera was added as per ISS procedures for Skin Rash (MOD, 2011). The amount of Triamcinolone was changed from 0 to 0.1 for best case and from 0 to 1.0 for worst case.

Required Resources Level of Evidence (LOE)

The IMM level of evidence appropriate assessment of the quality of the IMM input data. Since IMM incorporates input data from a wide variety of sources including astronaut population, terrestrial or analog populations, and external models, an innovative approach to assess the quality of input data was required. Information obtained from the astronaut population and/or space flight is the more relevant so it is assigned the highest level of evidence and less relevant data sources are assigned a lower level of evidence.

Citation	LOE Value	LOE Category
NASA Mission Operations Directorate (MOD), 2011	2	Resources

Level Of Evidence

Input Data	LOE Average
Incidence	1
Functional Impairment	3
Best Case / Worst Case	1
EVAC / LOCL	5
Resources	2
QUALITY OF EVIDENCE	**2.4**

Description	Range
Excellent	1-2
Good	2.1-3
Fair	3.1-4
Poor	4.1-5

Reference List

Reference
Alexandroff AB, Gawkrodger DJ. Update on contact dermatitis 2007: Medical pearls from the annual meeting of the British Contact Dermatitis Society at the annual meeting of the British Association of Dermatologists. J Dermatol Sci 2008 Sep;51(3):220-3.
American Medical Association. Skin. In: Rondinelli R, editor. Guides to the Evaluation of Permanent Impairment. 6th ed. Chicago: American Medical Association Press; 2008. p. 159-82.
Beltrani VS, Boguneiwicz M. Atopic dermatitis. Dermatol Online J 2003 Mar;9(2):1.
Billica RD, Simmons SC, Mathes KL, McKinley BA, Chuang CC, Wear ML, et al. Perception of the medical risk of spaceflight. Aviat Space Environ Med 1996 May;67(5):467-73.
Cherry DK, Burt CW, Woodwell DA. National Ambulatory Medical Care Survey: 2001 summary. Adv Data 2003 Aug 11;(337):1-44.
Drago F, Rampini E, Rebora A. Atypical exanthems: morphology and laboratory investigations may lead to an aetiological diagnosis in about 70% of cases. Br J Dermatol 2002 Aug;147(2):255-60.
Dworzak MN, Froschl G, Printz D, Fleischer C, Potschger U, Fritsch G, et al. Skin-associated lymphocytes in the peripheral blood of patients with atopic dermatitis: signs of subset expansion and stimulation. J Allergy Clin Immunol 1999 May;103(5 Pt 1):901-6.
Hanifin JM, Cooper KD, Ho VC, Kang S, Krafchik BR, Margolis DJ, et al. Guidelines of care for atopic dermatitis, developed in accordance with the American Academy of Dermatology (AAD)/American Academy of Dermatology Association "Administrative Regulations for Evidence-Based Clinical Practice Guidelines". J Am Acad Dermatol 2004 Mar;50(3):391-404.
Hanifin JM, Reed ML. A population-based survey of eczema prevalence in the United States. Dermatitis 2007 Jun;18(2):82-91.
International Space Station Program. Medical Standards and Certification Procedures For Space Flight Participants. NASA; 2002.
Kerstman EL. Schema for determination of Functional Impairment. Lopez V, editor. 4-14-2010. 4-14-2010.
Kerstman EL, Ilcus LS, Johnston SL, III, Moynihan S, Marshall GD. Rashes on Space Flights. 2010 Feb 4; 2010.
Larsen FS, Hanifin JM. Epidemiology of atopic dermatitis. Immunol Allergy Clin North Am 2002;22(1):1-24.
Leung DYM, Nicklas RA, Li J, Bernstein L, Bleassing-Moore J, Boguneiwicz M, et al. Disease management of atopic dermatitis: an updated practice parameter. Annals of Allergy, Asthma & Immunology 2004 Sep;93:S1-S21.
Marshburn TH. Acute Care. In: Barratt M, Pool S, editors. Principles of Clinical Medicine for Space Flight.New York: Springer; 2008. p. 101-22.
Merck Manual. Atopic Dermatitis - Contact Dermatitis. Porter RS, editor. Merck Manuals Online Medical Library . 2009. Whitehouse Station, N.J, Merck Sharp & Dohme Corp.. 6-8-2010.
NASA Mission Operations Directorate (MOD). International Space Station Integrated Medical Group Medical Checklist. Mission Operations Directorate (MOD), Systems Operations Data File (SODF) . 6-24-2011. Houston, TX, National Aeronautics and Space Administration (NASA).
Pitts SR, Niska RW, Xu J, Burt CW. National Hospital Ambulatory Medical Care Survey: 2006 emergency department summary. Natl Health Stat Report 2008 Aug 6;(7):1-38.
Risin D. Risk of Inability to Adequately Treat an Ill or Injured Crew Member. In: McPhee JC, Charles JB, editors. Human Health and Performance , Risks of Space Exploration Missions.Houston: National Aeronautics and Space Administration; 2009. p. 239-49.
Saile L., Boley L, Kerstman E. Integration RWS ISS STS Observed Incidence V2. 2017.
Saile L., Boley L, Arellano J, Kerstman E. iMED Best and Worst Case Percentage Update. 2017.
Saile L, Boley L, Kerstman E. Integration RWS ISS STS Observed Incidence. 2017.
Summers RL, Johnston SL, Marshburn TH, Williams DR. Emergencies in space. Ann Emerg Med 2005 Aug;46(2):177-84.
Thomas TL, Garland FC, Mole D, Cohen BA, Gudewicz TM, Spiro RT, et al. Health of U.S. Navy submarine crew during periods of isolation. Aviat Space Environ Med 2003 Mar;74(3):260-5.
Thyssen JP, Linneberg A, Menne T, Johansen JD. The epidemiology of contact allergy in the general population--prevalence and main findings. Contact Dermatitis 2007 Nov;57(5):287-99.

Reference

Tronnier H, Wiebusch M, Heinrich U. Change in skin physiological parameters in space--report on and results of the first study on man. Skin Pharmacol Physiol 2008;21(5):283-92.

Turner S, Carder M, van TM, McNamee R, Lines S, Hussey L, et al. The incidence of occupational skin disease as reported to The Health and Occupation Reporting (THOR) network between 2002 and 2005. Br J Dermatol 2007 Oct;157(4):713-22.

Walton M, Kerstman E, IMM. In-flight Compilation v20100414_Incidence_calculation. 2010.